1984 ANNUAL REPORT

to the

GOVERNMENTS OF CANADA, UNITED STATES, SASKATCHEWAN AND MONTANA

by the

POPLAR RIVER BILATERAL MONITORING COMMITTEE

COVERING CALENDAR YEAR 1984

March, 1985

POPLAR RIVER BILATERAL MONITORING COMMITTEE

REPORT TO GOVERNMENTS OF CANADA, UNITED STATES,

SASKATCHEWAN AND MONTANA

FOR

CALENDAR YEAR 1984

MARCH, 1985

POPLAR RIVER BILATERAL MONITORING COMMITTEE

Department of State
Washington, D.C., United States

Department of External Affairs
Ottawa, Ontario, Canada

Governor's Office, State of Montana
Helena, Montana, United States

Saskatchewan Environment
Regina, Saskatchewan, Canada

Gentlemen:

During 1984, the Poplar River Bilateral Monitoring Committee continued to fulfill the responsibilities assigned by the governments under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. Water quantity, water quality, and air quality relevant to the International Boundary were monitored in accordance to the 1984 Technical Monitoring Schedule. The monitoring data were exchanged on a quarterly basis. Herein is the report of activities of 1984 and the proposed monitoring schedule for 1985.

The report summarizes current conditions relative to pre-project conditions and compares current conditions to guidelines for specific parameter values that were developed under International Joint Committee references. References are made to State, Provincial, or Federal standards or objectives where these are relevant. After examination and evaluation of the monitoring information for 1984, the Committee finds that the measured conditions are within the norms of the accepted objectives.

During 1984, ground-water monitoring in Montana south of the coal mine was intensified to better assess potential transboundary impacts of the cone of depression associated with coal-seam dewatering. The Committee was informed that operation of the present mine will be phased out during the next 5 years and that new mines will be developed 10 to 15 kilometers to the east and northeast of the present mine. A goal of the Committee during 1985 will be to recommend additions and modifications to the Technical Monitoring Schedule to ensure that all potential impacts to transboundary waters from the new mine can be detected and monitored.

This letter serves as as reminder that the initial 5 year term of the Cooperative Monitoring Arrangement expires in September 1985. Article 5, Terms of Arrangement, addresses the provisions of renewal.

Yours sincerely,

J. R. Knapton
Chairman, United States Section

G. W. Howard
Chairman, Canadian Section

B. Hayden
Member, United States Section

W. Gummer
Member, Canadian Section

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1984 HIGHLIGHTS

1984 was the first full year of operation for two 300 megawatt coal-fired units. Over 4,180,000 gross megawatt hours of electricity were generated. The number of start-ups was down to 29 compared to 58 in 1983. As a result the consumption of oil changed from 13,756 to 3,788 tonnes, a 72 percent decrease.

Monitoring information collected in both Canada and the United States was exchanged on a quarterly basis. In general the sampling locations, frequency of collection, and parameters met the requirements identified in the Technical Monitoring Schedules. Air quality monitoring in Montana did not start until July in order that the 1 year of continued funding provided by the Montana Legislature could be used to monitor the project at near-capacity operation.

The United States received a continuous flow in the East Poplar River throughout the year which exceeded the minimum flow requirements recommended by the International Joint Commission to Governments. On April 10, 1984, Montana requested delivery of the 370 cubic decametres of on-demand release it is entitled to. The requested amount was not delivered in the 30-day period requested but was delivered within 39 days. The runoff in the basin was again well below normal during 1984.

The boron and total dissolved solids concentrations in the East Poplar River were below the long-term and short-term objectives recommended by the International Joint Commission to Governments. There was one minor exceedance of other water quality objectives recommended to Governments by the International Joint Commission. The

dissolved aluminum concentration in a June 17 sample was 0.11 milligram per litre, which was 0.01 milligram per litre above the recommended value. Investigations of U.S. Geological Survey and Environment Canada quality assurance data have identified potential incompatibility with parameters (boron, lead, zinc, and iron).

The outer limit of the cone of depression from coal seam dewatering moved closer to the International Boundary. Several new observation wells were established by the Montana Bureau of Mines and Geology south of the border with the assistance of the Saskatchewan Power Corporation.

The total estimated seepage from the ash lagoons and polishing ponds was 0.556 litre per second, well below the seepage limits proposed by the International Poplar River Water Quality Board. The leachate front has been calculated to have advanced 2.5 metres towards Cookson Reservoir since the ponds were first filled.

Plant stack emissions did not cause or contribute to violation of Montana, United States, or Saskatchewan ambient air quality standards.

During the year the Saskatchewan Power Corporation sold the coal mine to private interests. The private interests hold coal properties elsewhere in the area and propose to close the existing mine in about 5 years.

INTRODUCTION

The Poplar River Bilateral Monitoring Committee was authorized by the Governments of Canada and the United States under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. A copy of the Arrangement is attached to this report as Annex 1.

The Committee is composed of representatives of the Government of the United States of America, State of Montana, Government of Canada and Province of Saskatchewan. In addition to the representatives of Governments, two ex-officio members who are local representatives of the State of Montana and Province of Saskatchewan participate in the activities of the Committee. During 1984, the members and ex-officio members of the Committee were:

Mr. J. R. Knapton
U.S. Geological Survey
Cochairman, U.S. Section

Mr. T. E. Gallagher[1]
Governor's Office
Member, U.S. Section

Mr. C. W. Tande
Daniels County Commissioner
Ex-officio Member, Montana

Mr. D. A. Davis
Environment Canada
Cochairman, Canadian Section
(January - September 1984)

Mr. G. W. Howard
Saskatchewan Environment
Member, Canadian Section
(January - September 1984)
Acting Cochairman
(October - December 1984)

Mr. W. D. Gummer
Environment Canada
Acting Member, Canadian Section
(October - December 1984)

Mr. J. R. Totton
Reeve, R. M. of Hart Butte
Ex-officio Member, Saskatchewan

[1]Mr. Brace Hayden replaced Mr. T. E. Gallagher in February 1985.

The monitoring programs are in response to potential impacts of a transboundary nature resulting from Saskatchewan Power Corporation's coal-fired thermal generating station and ancillary operations near Coronach, Saskatchewan. Monitoring is conducted in Canada and the United States at or near the International Boundary for quantity and quality of both surface water and ground water and for air quality. Participants from both countries, including Federal, Provincial, and State agencies, are involved in monitoring.

A responsibility of the Committee includes an ongoing quarterly exchange of data acquired through the monitoring programs. The exchange of monitoring information was initiated with the first quarter of 1981, and is an expansion of the informal quarterly information exchange program initiated between Canada and the United States in 1976. Special reports dealing with aspects of monitoring and monitoring results are sometimes published. Any such reports are reviewed annually by the Committee. No such reports were received by the Committee in 1984. Exchanged data and reports are available for public viewing at the agencies of the participating governments or from Committee members.

The Committee also is responsible for an annual report to Governments which summarizes the monitoring results, evaluates apparent trends, and compares the data to objectives or standards recommended by the International Joint Commission (IJC) to Governments, or relevant State, Provincial, or Federal standards. The Committee reports to Governments on a calendar year basis, with the report for 1984 being the fourth report in the series. The Committee is also responsible for drawing to the attention of Governments definitive changes in monitored parameters which may require immediate attention.

Another responsibility of the Committee is to review the adequacy of the monitoring programs in both countries and make recommendations to Governments on the Technical Monitoring Schedules. The Schedules are updated annually for new and discontinued programs and for modifications in sampling frequencies, parameter lists, and analytical techniques of ongoing programs. The Technical Monitoring Schedules listed in the annual report (Annex 2) are given for the forthcoming year. The Committee will continue to review and propose changes to the Technical Monitoring Schedules as information requirements change.

POPLAR RIVER POWER STATION

Operation

The two units operated for the full reporting period. The 1984 operating statistics for the two units are shown in Table 1:

Table 1. 1984 Operating Statistics for Generating Units No. 1 and No. 2

	Unit 1	Unit 2
Hours of Operation	7 834	8 144
Gross MWhr Generated	2 063 200	2 117 700
Availability (hours)(percent)	89.2	92.7
Capacity Factor(percent)	78.8	82.0
Number of Start Ups	18	11
Coal Consumed (tonnes)	1 727 393	1 766 393
Oil Consumed (tonnes)	2 341	1 447
Hours in Period	8 784	8 784

The average sulphur content as analyzed by the Power Station's Laboratory in 1984 was 0.8 percent. Inter-lab testing of standard coal samples indicates that the station's method of analysis (bomb washing titration) is systematically biased high. During 1984, the results of such round robin analyses indicated that these results were, on average, 53 percent greater than the mean of all the other laboratories.

The average of three samples of the coal analyzed in 1984 by the Eschka method was 0.48 percent sulphur. The Eschka method is described in the 1976 Edition of the "American Society for Testing and Materials," procedure D3177-75.

The sulphur content of the No. 2 fuel oil consumed at the Poplar River Power Station varied from 0.06 to 0.08 percent in 1984.

On May 16, 1984 approximately 3 200 litres of Ferri-Floc solution (50 percent $Fe_2 (SO_4)_3$) were spilled as a result of a drain pipe failure on a holding tank. The spill was contained upstream of the first spill containment structure in the ditch south of the plant. Spill cleanup procedures were implemented and none of the spill materials entered Cookson Reservoir.

Construction

Concrete and stoplog overflow structures were constructed between No. 1 and No. 2 ash lagoons and between No. 2 ash lagoon and the polishing pond. The structures provide better ash lagoon water level control and improve the lagoon management system. A waste water pond, overflowing into the polishing pond, was created at the northwest corner of No. 1 ash lagoon to facilitate the revised lagoon operating regime. The work was completed in October 1984.

An online ball type recirculation condenser cleaning system was purchased, installed on Unit 2 and commissioned in October 1984. The cleaning system, using charges of plain sponge rubber balls and intermittent charges of ceramic coated balls, mechanically removes scale and marine growth from the circulating water side of the condenser tubes. The balls are continuously injected into the condenser cooling water inlet, circulated through the condenser tubes, collected by a screen in the condenser cooling water outlet, and pumped back to the inlet. Scale inhibitor chemical dosing at the condenser inlet was discontinued.

The Saskatchewan Power Corporation assisted in the installation of seven piezometers in Montana during the period September 6, 1984 to September 25, 1984. The piezometer locations were selected by the Montana Bureau of Mines and Geology.

The Poplar River Coal Mine near Coronach was purchased by Prairie Coal Limited in 1984.

Coal mining is expected to continue at the site to the west of Girard Creek until December 1989. Additional mine dewatering wells are expected to be installed in 1985.

By 1990, mining operations are expected to be relocated to the Willow Bunch South Mine (east of the upper end of Cookson Reservoir) or to the Willow Bunch North Mine (located north of Cookson Reservoir).

Both areas have a better quality coal and are expected to be drier than the Poplar River Mine.

SURFACE WATER QUANTITY

Streamflow

Streamflow in the Poplar River basin was below normal during 1984, assuming the recorded flow of the Poplar River at the International Boundary is a good indicator of basin runoff conditions. The March to October recorded flow volume at that gauge was 8 790 cubic decametres (dam^3), or 53 percent of the 1931-83 average, and would have been one of the lowest on record except for a single period of rainfall in June which produced about 2 800 dam^3 of runoff.

Dewatering operations at the Poplar River Mine have resulted in a small quantity of water being discharged into Goose Creek, a tributary of the Poplar River. Little, if any, of this water reached the International Boundary in 1984.

The recorded flow volume of the East Poplar River at the International Boundary for 1984 was 2 900 dam^3, or 20 percent of the mean annual flow since the completion of Morrison Dam in 1975.

Minimum Flows

The recorded runoff volume of the Poplar River at the International Boundary from March 1 to May 31, 1984 was 5 480 dam^3. For the purposes of interpreting the apportionment recommendations of the IJC, the recorded flow is assumed to be the natural flow. Based on these recommendations, this volume entitled the United States to a minimum

discharge of 0.057 cubic metre per second (m^3/s) from June 1 to August 31, 1984 and 0.028 m^3/s from September 1, 1984 to May 31, 1985 on the East Poplar River at the International Boundary. The March 1 to May 31, 1983 Poplar River volume had previously entitled the United States to a minimum flow of 0.028 m^3/s for the first 5 months of 1984.

The recorded flow of the East Poplar River at the International Boundary exceeded the recommended minimum throughout the year. A minimum daily discharge of 0.065 m^3/s occurred on several days in July, August, and December.

A hydrograph of flow in the East Poplar River at the International Boundary is depicted in Figure 1. The minimum flow as recommended by the IJC is also shown.

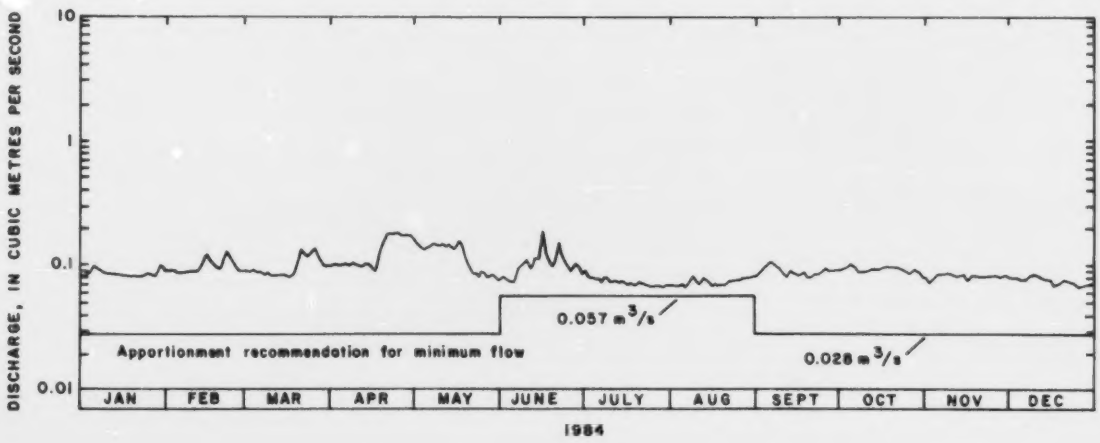


Figure 1. Hydrograph of Water Discharge of the East Poplar River at the International Boundary and Recommended Minimum Flow.

Reservoir Storage

Cookson Reservoir was near the full-supply level all year, rising from an elevation of 752.320 metres (m) on January 1 to a maximum water level of 752.836 m on April 15. Elevations and volumes of stored water for selected dates are given in Table 2.

Table 2. Reservoir Storage Statistics for 1984

Date (1984)	Elevation (metres)	Volume (cubic decametres)
January 1	752.320	38,300
April 15	752.836	42,200
December 31	752.149	37,000
Full-Supply Level	753.000	43,400

Storage decreased during the year by 1 300 dam^3, and would have decreased even more during the hot and dry summer if base flows in Girard Creek had not been maintained by dewatering operations at the Poplar River Mine. These flows assisted in offsetting the evaporative losses and releases from the reservoir. Based on present conditions, most of the predicted runoff for 1985 can be stored in the reservoir.

On-Demand Release

Based on the apportionment recommendations of the IJC, the United States is entitled to an on-demand volume of 617 dam^3 at any time from June 1, 1984 to May 31, 1985. As of December 31, 1984 Montana had not requested this release. The on-demand volume entitlement for 1983 of 370 dam^3 was requested on April 10, 1984 to be delivered April 15 to May 15. This volume was delivered April 16 to May 24.

Data Compatibility

The 1984 surface water quality data indicate that most of the analytical and sampling procedures of the U.S. Geological Survey and Environment Canada are generally compatible, although data indicate significant differences in four parameters for one sampling period (Table 3). Quality assurance sampling was conducted at the East Poplar River at the International Boundary by the two agencies on September 12, 1984 and provided triplicate samples for analysis by each of the respective laboratories.

Table 3. Incompatibility of Analytical Results of Four Parameters from the East Poplar River at the International Boundary, September 12, 1984 [units are reported in milligrams per litre (mg/L) and micrograms per litre (µg/L)]

Parameter \ Triplicates	Environment Canada			U.S. Geological Survey		
	1	2	3	1	2	3
Boron (mg/L)	1.3	1.3	1.3	1.8	1.8	1.8
Iron - dissolved (µg/L)	80	80	100	11	14	12
Lead - (µg/L)*	< 1	< 1	< 1	1	5	7
Zinc - (µg/L)*	2	2	2	6	7	5

*Note - U.S. Geological Survey reports dissolved, Environment Canada reports total

The most important analytical incompatibility was with boron where concentrations differed by more than 30 percent. A comparison of field to laboratory specific conductances suggests that field instru-

mentation requires assessment. It is difficult to comment on the compatibility of methods relating to zinc and lead, because the Geological Survey uses a dissolved method and Environment Canada uses a total method. Although the data appear incompatible, the concentrations were near laboratory detection levels and well below the proposed objectives (Table 4). The agency results for dissolved iron were incompatible during the September quality assurance survey. Because of the low concentrations for lead and zinc and the fact that iron is not addressed in the objectives, only boron is a major concern of the sample results.

Particular attention will be given by government agencies in 1985 to further clarify the interagency compatibility for the above noted parameters.

Flow-Weighted Concentrations for Comparison to the IJC Objectives

The 1981 report by the IJC to Governments recommended:

> *For the March to October period, a maximum flow-weighted concentration should not exceed 3.5 mg/L for boron, and 1 500 mg/L for total dissolved solids for any three consecutive months in the East Poplar River at the International Boundary.*

> *For the March to October period, a long-term average of flow-weighted concentrations should be 2.5 mg/L or less for boron, and 1 000 mg/L or less for total dissolved solids in the East Poplar River at the International Boundary.*

Compliance of the East Poplar River water quality with the proposed short-term objectives for boron and total dissolved solids (TDS) is tested by calculating the 3-month (90-day) moving flow-weighted concentration for each and advancing 1 month at a time while dropping the first month of the 3-month period. Prior to 1982, determination of compliance was based strictly on instantaneous samples. Since the beginning of 1982, daily TDS and boron concentrations have been computed from a regression relationship with specific conductance. However, the data from both instantaneous samples and from calculation of TDS and boron have been presented.

The Bilateral Monitoring Committee has adopted the approach that for the purpose of determining compliance with the proposed IJC long-term objectives, the boron and TDS data are best presented as a 5-year, flow-weighted moving average which is advanced 1 month at a time.

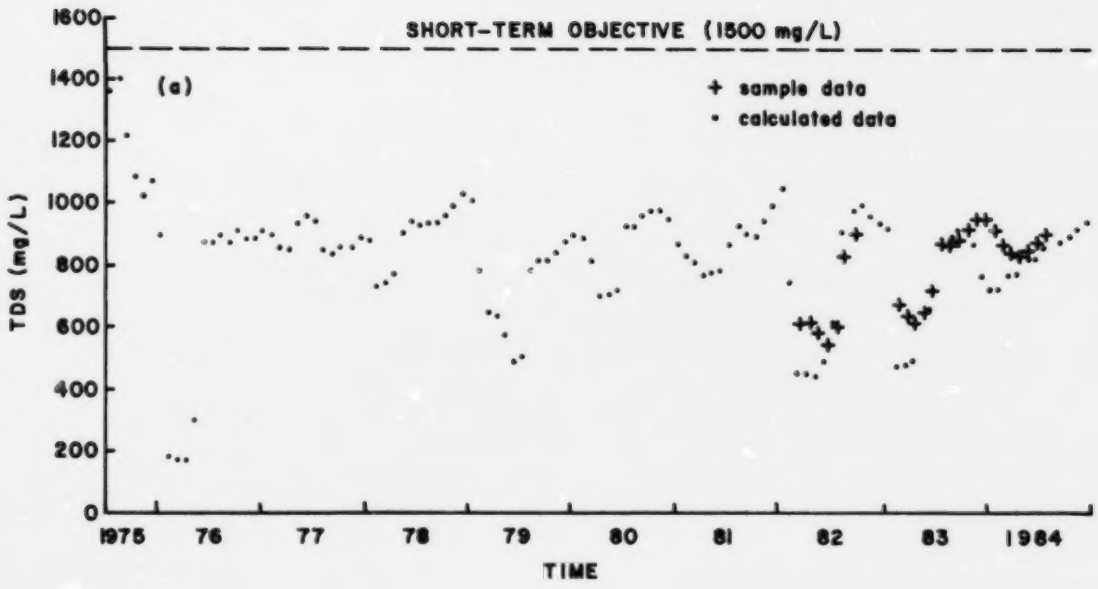
East Poplar River at the International Boundary

Total Dissolved Solids

The proposed short-term objective for TDS is 1 500 milligrams per litre (mg/L). A plot of the 3-month moving flow-weighted concentrations is shown in Figure 2. No exceedances occurred in 1984 at the International Boundary. The maximum 3-month, flow-weighted concentration during the irrigation season was 869 mg/L. The calculated minimum observed was 734 mg/L. The observed relationship between TDS and specific conductance is:

$$TDS = (0.654 \times \text{specific conductance} - 6.86) \qquad (R^2 = 0.902)$$

The long-term, 5-year moving flow-weighted concentrations for TDS are shown in Figure 2. The long-term, flow-weighted values, as well as



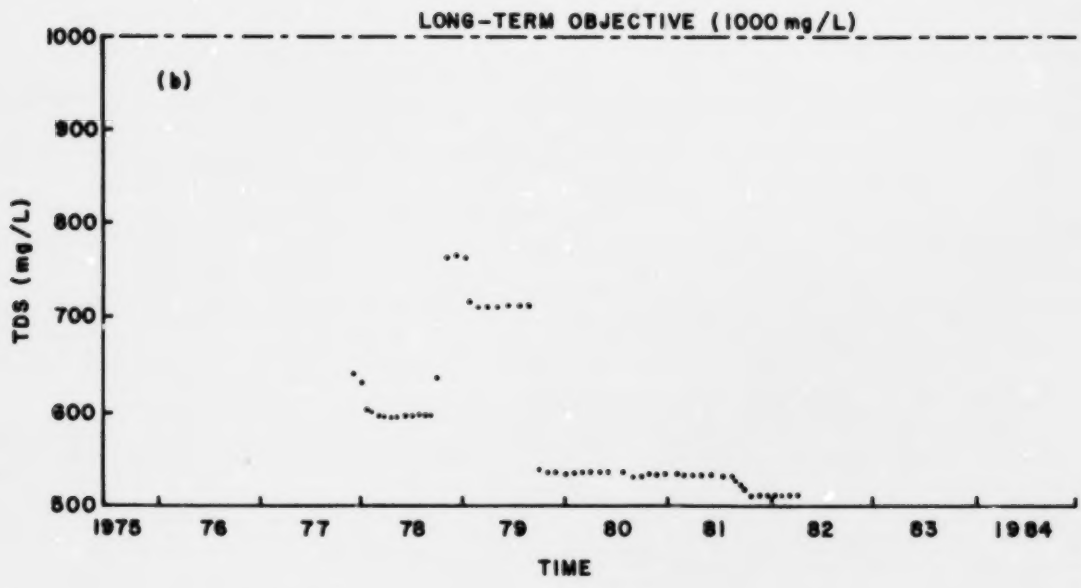


Figure 2 (a) Three-month Short-term Flow-weighted Concentration for TDS, East Poplar River at the International Boundary; (b) Five-year Long-term Flow-weighted Concentration for TDS, East Poplar River at the International Boundary

all the observed instantaneous concentrations, remained well below the proposed objective of 1 000 mg/L.

Boron

The proposed short-term objective for boron is 3.5 mg/L. Figure 3 shows the 3-month moving flow-weighted concentrations for boron. There were no exceedances over the period of record (1975 to 1984). The maximum 3-month, flow-weighted concentration for boron during the 1984 irrigation period calculated from the regression equation was 1.79 mg/L. Using the instantaneous data set a maximum boron concentration was calculated to be 1.86 mg/L.

Boron concentrations used in the flow-weighting computation were calculated from daily specific conductance values, using the regression equation:

$$B = (0.00149 \times \text{specific conductance}) - 0.31 \qquad (R^2 = 0.79)$$

The trend in each annual curve is similar. As autumn approaches, the 3-month, flow-weighted concentrations rise gradually as the ground water contribution accounts for a greater percentage of the streamflow. In 1984, however, the dip in concentration during spring runoff is less pronounced than in most previous years, probably owing to a comparatively small amount of spring runoff.

The long-term, 5-year moving flow-weighted mean concentration is presented in Figure 3. Each point is plotted at the midpoint of a 5-year period, advancing 1 month at a time through the data set. Although only the irrigation season (March to October) was of concern to the IJC, all yearly values are included in Figure 3, to better

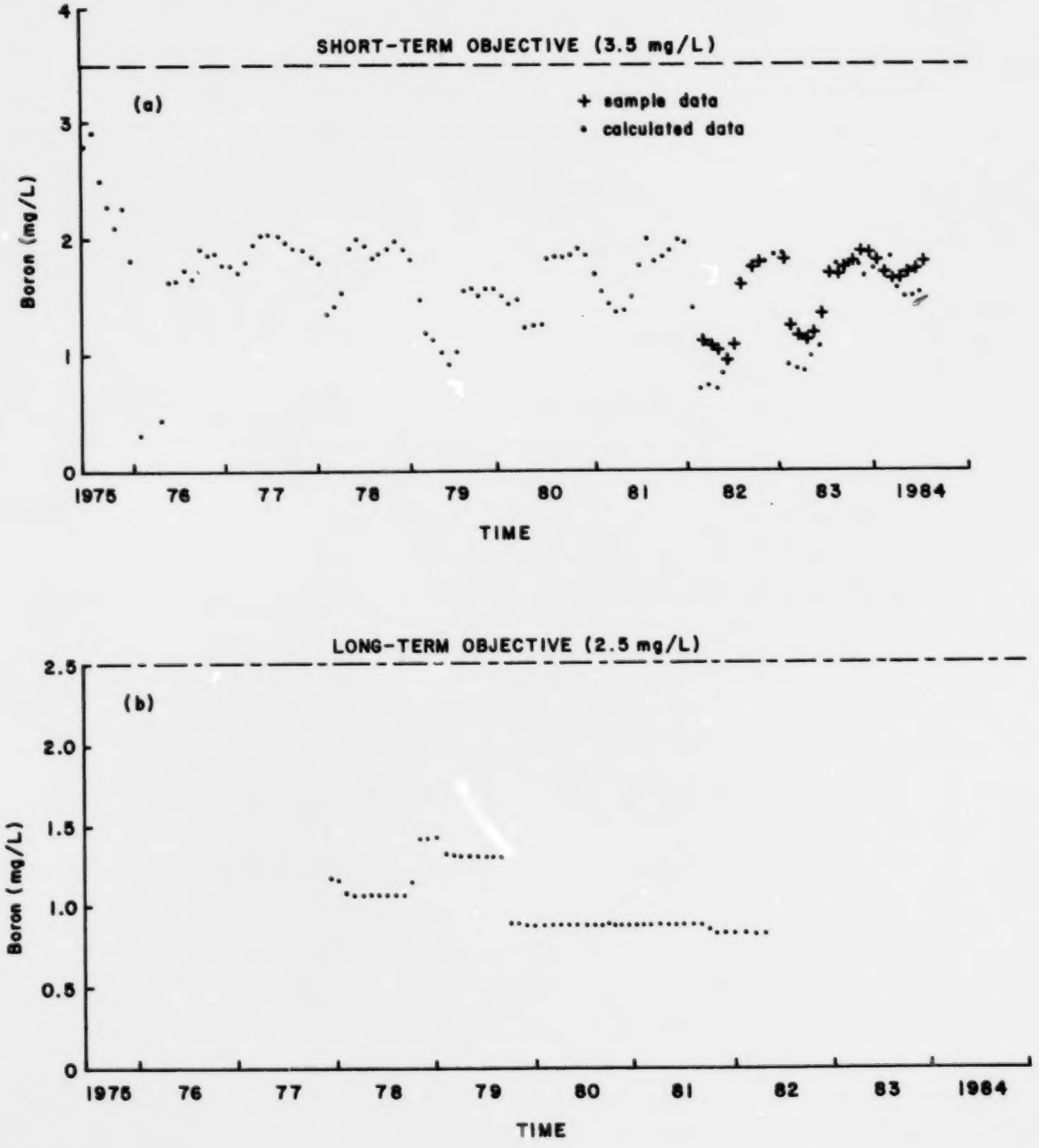


Figure 3 (a) Three-month Short-term Flow-weighted Concentration for Boron, East Poplar River at the International Boundary; (b) Five-year Long-term Flow-weighted Concentration for Boron, East Poplar River at the International Boundary

present the long-term trends in the data. The 5-year, moving flow-weighted concentration for boron does not exceed the 2.5 mg/L recommended long-term objective. The maximum value for the period, 1975 to December 1984, is 1.46 mg/L, plotted for January 1979.

Other Water Quality Characteristics

Table 4 shows the multi-purpose water quality objectives recommended by the International Poplar River Water Quality Board to the IJC. The number of samples collected for each parameter by Canadian and United States agencies is also shown. One dissolved aluminum concentration of 0.11 mg/L was reported on the 17th of June. This single value is not considered to be significant, however, as it is only 0.01 mg/L above the objective of 0.10 mg/L. Other than this one anomalous value, the recommended objectives were met for the East Poplar River at the International Boundary.

The inverse relationship on the East Poplar River that existed between specific conductance and streamflow prior to construction of Cookson Reservoir remains, but has been modified somewhat as a result of reservoir mixing and controlled releases. During periods of high runoff, such as the spring freshet, the specific conductance decreases, as the proportion of streamflow derived from ground water decreases. Conversely, during times of low streamflow (late summer, winter) the contribution of ground water to streamflow is proportionately greater. Because the natural ground water has a higher ionic strength than does the surface water entering the river, the specific conductance of the stream increases markedly during periods of reduced flow.

With the exception of a sample taken on August 8, 1984, the Environment Canada data indicated that the mercury content was at or below

Table 4. Recommended Water-quality Objectives and Exceedances and the 1984 Sampling Program, East Poplar River at the International Boundary (units in milligrams per litre, except as otherwise noted).

Parameter	Objective	No. of samples (1984) USA	Canada	Exceedances
Objectives recommended by IJC to Governments				
Boron - total	Note 1	11	12	Nil
TDS	Note 1	11	12	Nil
Objectives recommended by Board to IJC				
Aluminum - dissolved	0.1	2	12	1
Ammonia - un-ionized	0.2	11	12	Nil
Cadmium - total	0.0012	1	12	Nil
Chromium - total	0.05	1	8	Nil
Copper - dissolved	0.005	2	Nil	Nil
Copper - total	1.0	1	12	Nil
Fluoride - dissolved	1.5	11	12	Nil
Lead - total	0.03	1	12	Nil
Mercury - dissolved	0.0002	Nil	Nil	Nil
Mercury - whole fish (mg/kg)	0.5	Nil	Nil	Nil
Nitrate - N	10.0	11	12	Nil
Dissolved oxygen	Note 2	14	12	Nil
Sodium adsorption ratio	10.0	11	12	Nil
Sulphate	800.0	11	12	Nil
Zinc - total	0.03	1	12	Nil
Temperature (°C)	Note 3	14	12	Nil
pH	Note 4	14	12	Nil
Coliform - fecal (No./100 mL)	2,000/100 mL	Nil	12	Nil
- total	20,000/100 mL	Nil	12	Nil

Note

1. March to October, long-term average of flow-weighted concentrations should be $\leq$ 2.5 mg/L for boron, and $\leq$ 1 000 mg/L for TDS with a maximum flow-weighted concentration not to exceed 3.5 mg/L for boron and 1 500 mg/L for TDS for any 3-month period during this time.

2. 5.0 (minimum April 10 to May 15), 4.0 (minimum rest of year).

3. Natural (April 10 to May 15), less than 30°C (rest of year).

4. 6.5 (minimum) and less than 0.5 above natural.

the analytical detection limit of 0.02 microgram per litre (µg/L). The reported value of 0.06 µg/L observed on August 8, was anomalous, but still is much less than the proposed objective of 0.2 µg/L. Uranium data for 1984 are unavailable for the East Poplar River at the International Boundary but based on historical data are believed to be typical of background concentrations found in surface waters.

Cookson Reservoir

Data submitted quarterly by Saskatchewan Environment indicate that the TDS and boron concentrations of Cookson Reservoir discharge remained below 1 000 and 2.5 mg/L, respectively. The observed boron and TDS concentrations at the sampling site in the reservoir near the dam are generally somewhat higher than those observed at the upstream station near Highway 36, during 1984. As follow-up to its work in September 1983, Environment Canada conducted further sampling for mercury in water and sediment of Cookson Reservoir during 1984. Preliminary results on the samples indicate mercury levels in water to be below the analytical detection limit. A detailed report on the results of these mercury analyses is in preparation.

GROUND WATER QUANTITY

Saskatchewan

Pumpage from Coal Seam Dewatering Wells

The monthly pumpages from the coal dewatering wells are shown in Table 5.

Table 5. 1984 Dewatering Rates from Coal Seam Dewatering Wells

Month	Pumpages (Cubic Decametres)	Pumpages (Litres per Second)
January	665	248
February	655	261
March	638	238
April	659	254
May	720	269
June	643	248
July	685	256
August	648	242
September	573	221
October	569	213
November	626	241
December	683	255
TOTAL	7,764 dam^3 (6,294 acre-feet)	

Discharges

Water was discharged from 19 locations during 1984. The majority of the discharges were into Girard Creek; one discharge was directly

into Cookson Reservoir, and one discharge was into a tributary of Goose Creek. None of this water reached the main stem of Goose Creek.

Water Levels

Saskatchewan Power Corporation compiled a map (Figure 4) of the water level drawdown in the Hart Coal Seam, dated December 31, 1984.

The drawdown advanced somewhat towards the International Boundary. The 1-m contour of water level drawdown on the December 31, 1984 map was about 1.8 kilometres (km) north of the International Boundary, compared to 2.4 km a year earlier. The 5-m contour of water level drawdown was about 4.8 km north of the International Boundary, compared to 5.2 km in December 1983. Maximum drawdown of the water level in the Hart Coal seam at the pumping centre is 25 m.

Montana

Water levels in wells declined during most of 1984 in response to decreased precipitation, but the levels were rising in late 1984 with the exceptions of wells 5 and 6. Except for the possible effect on wells 5 and 6, there appears to be no impact from dewatering operations.

The Daniels County Conservation District obtained funding for the

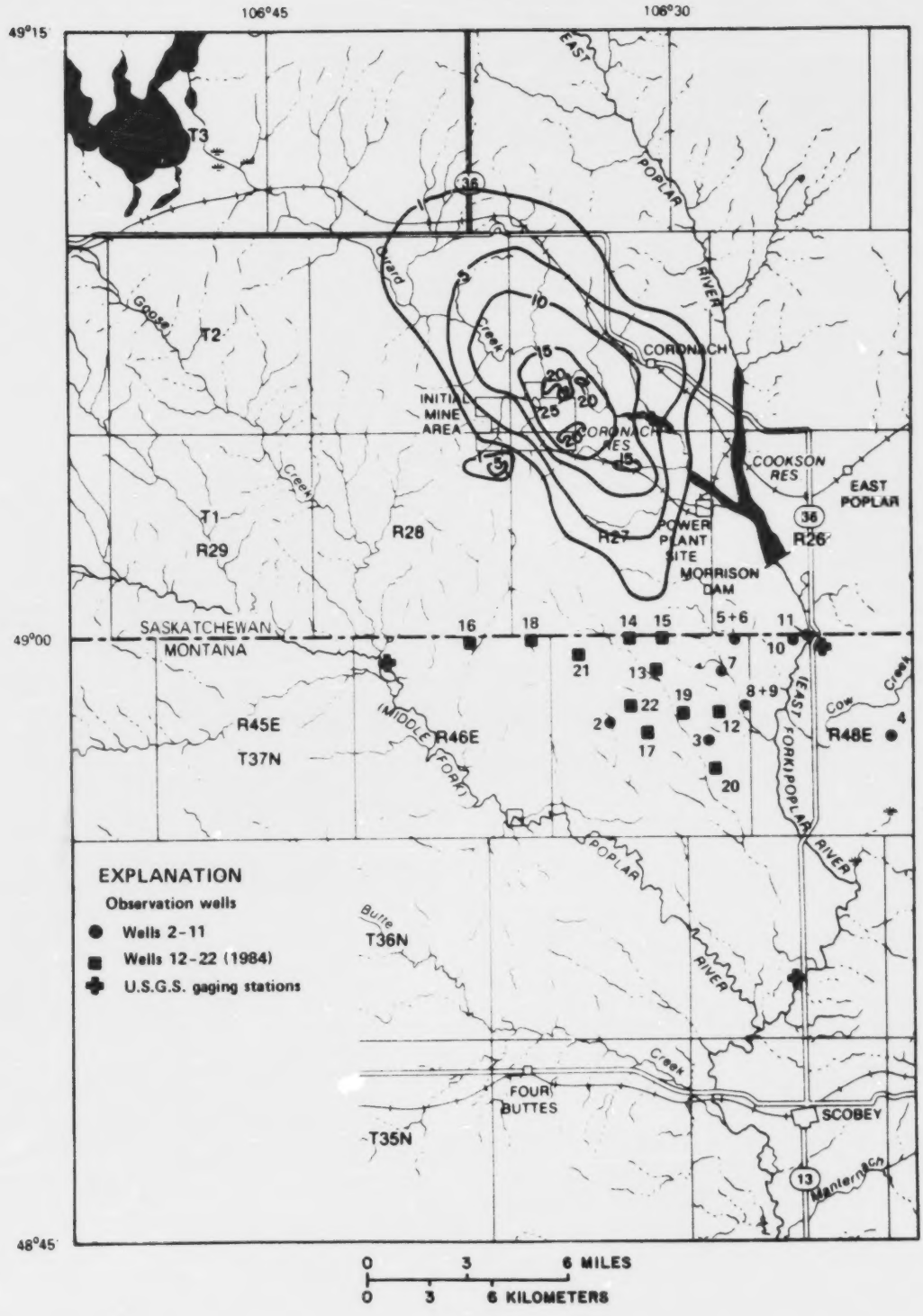


Figure 4. Cone of Depression in the Hart Coal Seam from Dewatering Activities as of December 1984.

East Fork Poplar River Ground-Water Monitoring Program in 1984. The funds were provided by the Montana Coal Board. Ground-water quantity and quality are being monitored utilizing 21 observation wells.

In 1984, 11 observation wells were drilled and added to the original network of 10 wells (Figure 4). Seven of these wells were drilled by the Saskatchewan Power Corporation. Nine wells were cased with 4-inch PVC and two with 2-inch PVC. Gamma, density and resistivity logs were run on all of the boreholes by the Saskatchewan Power Corporation.

Some development work on the wells was performed after drilling, but not sufficient to obtain good water quality samples. This work will be continued in the spring of 1985 when water will be sampled from these wells.

GROUND WATER QUALITY

Saskatchewan

Ground water sampling continued in 1984 at the locations specified in the Technical Monitoring Schedules. Piezometer C726B is considered to be naturally anomalous due to local soil conditions. Because of the extremely high and variable levels for major ions observed in this piezometer over the period of record, sampling was discontinued at the end of 1983.

Water Quality in the Tills

Waters from the tills are of generally poorer quality than those from the Empress Gravels. This is illustrated in Figure 5, where TDS has been plotted for each piezometer. The higher, and more variable concentrations were associated with piezometers completed in till, whereas TDS levels in the Empress-completed piezometers rarely exceed 1 200 mg/L. The differences in concentration observed both spatially and temporally in the tills can be attributed to localized geochemical conditions adjacent to the piezometer intakes.

Piezometer C712B at location 2a, just to the north of the polishing pond, does not display any consistent variation, or trend in water quality. Aluminum, boron, and strontium appear to have reached a yearly maximum in the July 4, 1984 sampling, but these values decrease again in the October 10, 1984 sampling. Locations 2b and 2c, also to the north of the polishing pond, likewise display no consistent water quality trends over the October 1983 to October 1984 period.

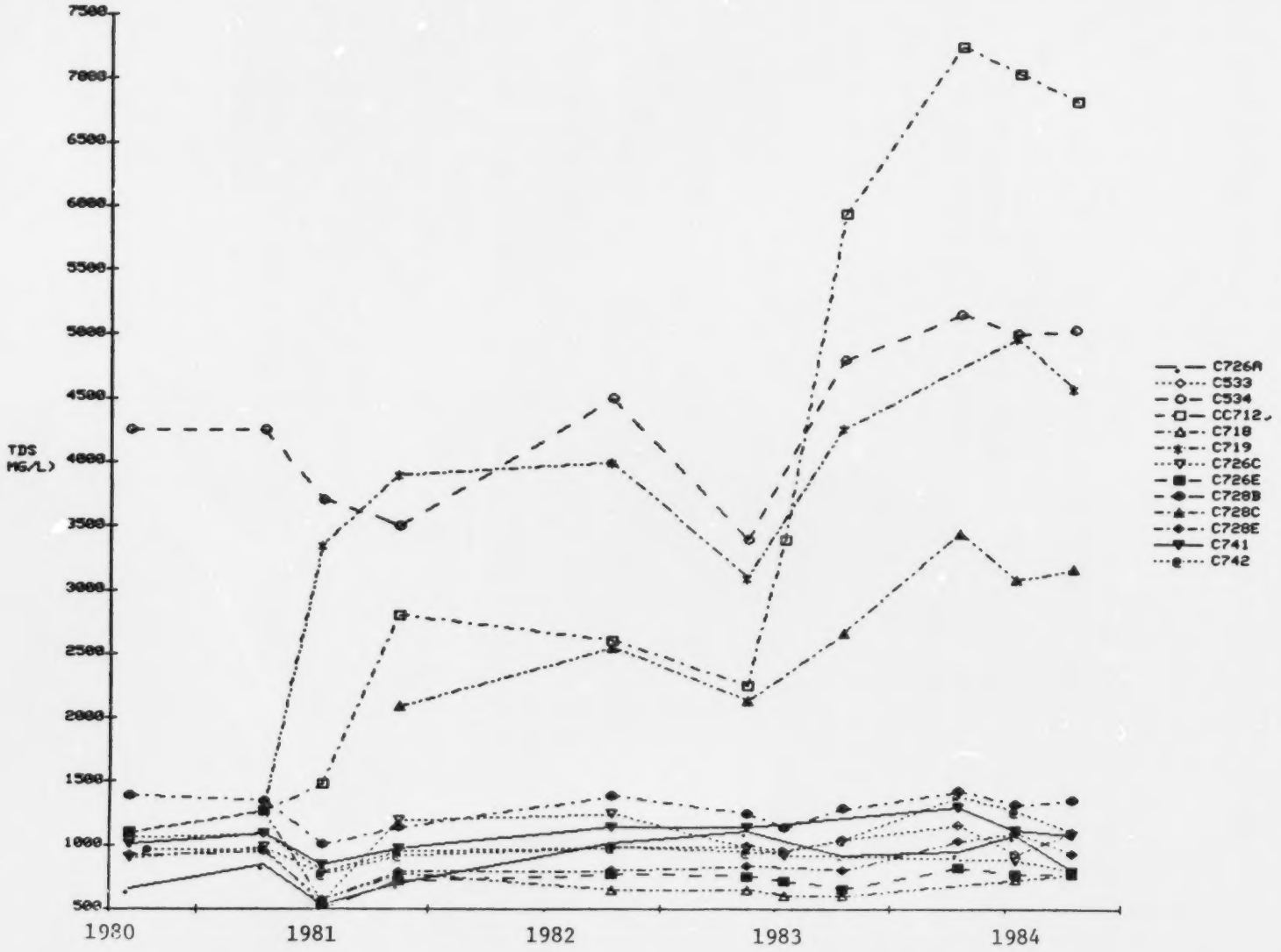


Figure 5. Total Dissolved Solids Concentrations, East Poplar River Monitoring Piezometers.

At location 9a, at the west end of the polishing pond, piezometer C728B shows somewhat elevated levels of uranium in the July 5, 1984 and October 12, 1984 samplings. These higher than usual values have occurred sporadically in samplings of previous years (for instance October 1982), but are not considered to be representative of any significant trend. Similar variability in uranium concentrations during 1984 is noted for piezometer C728C. Significant concentration trends with respect to uranium or to any other parameters in C728B or C728C are not apparent.

At location 8a, at the western edge of the ash lagoon No. 1, monitoring was discontinued in piezometer C726B after 1983, because of extremely high levels of various ions measured, and because of the extreme variability in concentration observed over time. It was assumed that these high concentrations and extreme variability were of a natural origin. Other piezometers completed in till at location 8a (C726A, C726C) display much more moderate hydrochemical variation. No particular trends in water quality have been noted over the period of record for either piezometer.

In piezometer C534, monitoring was continued in 1984. Iron and zinc analyses were discontinued, due to contamination from the galvanized steel casing. No significant trends were evident in any parameter over the entire period of record.

Water Quality in the Empress Gravels

The Empress Gravels form an important aquifer in the East Poplar River Basin. The associated ground waters are of a moderately high

alkalinity, and a predominantly calcium-magnesium bicarbonate type. Sulphate is the second most abundant anion.

At locations 2a (piezometer C726E), 9a (piezometer 728E), C533, C741, and C742, no significant overall water quality trends are apparent. During the 1984 meeting, the Bilateral Monitoring Committee recognized that, due to the galvanized steel pipe used in the construction of C533, iron and zinc concentrations from that piezometer have been unreliable. These two parameters, therefore, have not been reported in 1984.

Due to the absence of consistent water quality trends in the Empress Gravel, it appears that no significant amount of leakage from the lagoons, into the gravels, has occurred.

Montana

Water quality sampling was conducted in September 1984. Wells 5 through 11 were sampled utilizing a submersible pump; wells 3 and 4 using a gas lift sampler; and well 2 was bailed due to the depth of water.

The ground-water chemistry appears to be stable from year to year. Sulfide greater than 0.1 mg/L was detected only in samples from the two Fox Hills-Hell Creek wells (4 and 11) and from one Hart Coal well (2). The sulfide and sulfate values were used to calculate the redox potential for these three samples. These three waters all lie in the pyrite stability field. The water in well 11 is also saturated with respect to siderite. The high iron content (0.5 mg/L) of

water from well 11 may be at least partly due to the use of steel casing for that well. Additionally, well 2 still contains anomalous amounts of zinc (about 2 mg/L) believed to have been introduced during drilling.

ASH LAGOON QUALITY AND QUANTITY

The ash lagoon system at the Poplar River Power Plant continues to be operated on a closed system basis, with no discharges to surface waters. During 1984 sluiced ash was directed into both ash lagoons No. 1 and No. 2. In early fall, modifications to the control structure permitted series operation of ash lagoon No. 1, ash lagoon No. 2, and the polishing pond. Water from the polishing pond is returned to the plant for ash sluicing. Water depths in the operational ash lagoons No. 1 and No. 2 were in the 4.8-5.7 m and 2.3-3.1 m ranges, respectively.

Seepage was again calculated in 1984 using the methods developed by T. A. Prickett, P. E. of Urbana, Illinois. Results of the calculations for the ash lagoons No. 1 and No. 2 and the polishing pond are given in table 6.

Table 6. Calculated Seepage Rates from Ash Lagoons No. 1 and No. 2

Source	Rate (L/s)
Polishing Pond	0.183
Ash Lagoon No. 1	0.143
Ash Lagoon No. 2	0.230
TOTAL SEEPAGE	0.556

Although the calculated seepage appears to reflect the loading effects from ash lagoon No. 2, the total is well below the seepage limits (5.0 L/s to Cookson Reservoir and 2.0 L/s to the East Poplar River) proposed in 1979 by the International Poplar River Water Qual-

ity Board of the IJC. The permeabilities of ash lagoon No. 1 and No. 2 and polishing pond liners were calculated and found to be in the same order of magnitude (10^{-9} cm/s) as originally calculated by T. A. Prickett.

The leachate front advancement towards the reservoir is calculated to be 2.5 m since the ponds were initially filled. The water front in the Empress formation is calculated to have advanced to 484 m southeast of the lagoons. Based on Empress formation water chemistry information, lagoon effects were not observed. Leachate flow to Cookson Reservoir and to the East Poplar River was zero.

Saskatchewan Environment requires that Saskatchewan Power Corporation maintain the stability of the ash system lagoon dykes. In addition to the daily and monthly visual inspections, an annual investigation by a geotechnical engineer was conducted in early May 1984. The minimum freeboard of 1.47 m was exceeded in the polishing pond during two periods and in ash lagoon No. 1 in December 1984. The problem in the polishing pond was remedied by water transfer to ash lagoon No. 2. The level in Ash Lagoon No. 1 remained high because this lagoon is now full of ash. New control structures including the previous internal dyke (Lagoon No. 1 - Polishing pond) breach repair were completed in early fall to facilitate recirculation capabilities.

Saskatchewan Power Corporation has, since May 1983, undertaken analyses of filtered ash lagoon water samples to obtain appropriate information on potential leachate quality. Analysis of ash was also obtained. Based on 1983 and 1984 data comparisons, the expected increases in the ash lagoons and the polishing pond occurred for: sodium, potassium, chloride, sulphate, total dissolved solids, aluminum, boron, chromium, and zinc.

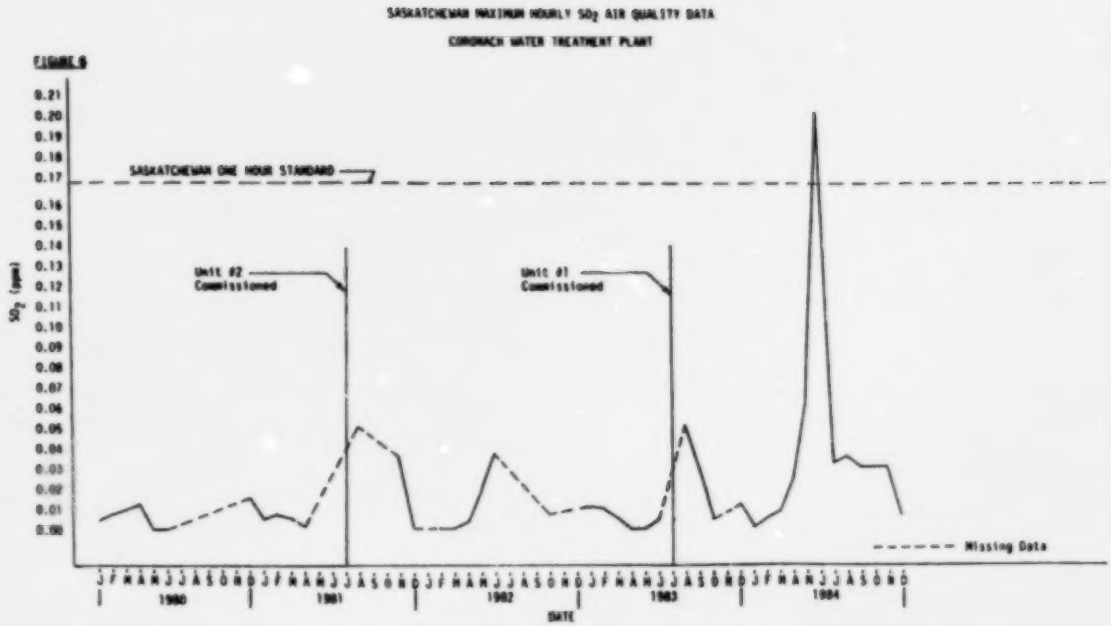
Ash lagoon No. 3 was not used in 1984 but 1 to 2 m of water were maintained in the lagoon to protect the clay liner from dessication and freezing.

AIR QUALITY

Saskatchewan

Ambient sulphur dioxide monitoring began at Coronach in July 1979. To date, a few detectable concentrations have been recorded at this site. There were two high concentrations during 1984, both occurring on June 22, at 1100 and 1200 hours. The levels were 20.3 and 17.0 parts per hundred million (pphm) respectively. Saskatchewan Environment's 1 hour air quality standard is 17.0 pphm (Figure 6). Weather information for this day indicates that winds for the entire 24 hour period were blowing mainly from the northwest quadrant. Since the plant is located south of the monitoring station it is unlikely that the plant was the source of the high readings. The source of the two readings has not been determined. The next highest reading of 6.0 pphm occurred on May 2 at 1830 hours. Weather information for this day indicates winds blowing from the southeast quadrant for the entire 24 hour period, which would indicate the power plant as the main source.

Suspended particulate concentrations at Coronach exceeded Saskatchewan Environment's 24-hour average standard of 120 micrograms per cubic metre ($\mu g/m^3$) on six occasions, as compared to four in 1983. In four of the cases, April 24, 30, and May 12, 24, weather information indicated winds blowing predominantly from the northwest quadrant, suggesting that the power plant was not the main source. Wind blown dust from fields north of the monitoring site was the most probable source. The other two instances occurred on June 29 and December 20. Weather data for these 2 days indicated wind directions mainly from the south, suggesting the power plant as a possible source of dust emissions. Power plant operating summaries for December 20 note a power trip of Unit No. 2 precipitator which caused violations of the opacity standard. However, the highest concentration in Montana was



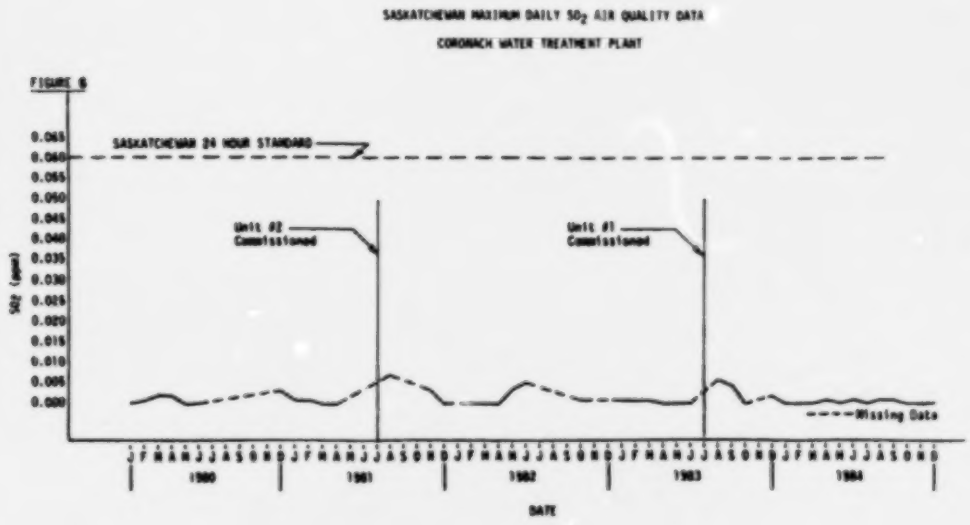


Figure 6. Sulphur Dioxide Air Quality Data - Coronach Water Treatment Plant.

also observed on December 20. The 1984 annual geometric mean of 39.8 $\mu g/m^3$ is still well below the Saskatchewan standard of 70.0 $\mu g/m^3$.

In-stack monitoring results showed less variance in 1984, as a result of improvements in plant operations. Daily nitrogen oxide concentrations ranged from 620 to 1 593 milligrams per cubic metre (mg/m^3) with an average yearly concentration of 800 mg/m^3 as compared to 900 mg/m^3 in 1983. However, operating problems continued to plague the nitrogen oxides monitor in 1984. As a result data from April to December are questionable and may represent only 50 percent of actual values. Daily sulphur dioxide concentrations ranged from 2 168 to 3 120 mg/m^3 with an average yearly concentration of 2 600 mg/m^3 as compared to 2 750 mg/m^3 in 1983. Sulphur dioxide emissions consisted of 1.3×10^{-3} tonnes per megawatt hour due to firing on coal and 1.5×10^{-6} tonnes per megawatt hour due to firing on oil.

Average daily opacity readings ranged from 18 to 76 percent, with a yearly average of 22 percent. Saskatchewan's opacity standard is 40 percent. In most instances, opacity violations occurred when one of the precipitators experienced a power trip.

Montana

The State of Montana operated three primary air monitoring sites and five additional sulfation rate sites in the Poplar River area of Montana from July 1984 through December 1984. The parameters monitored included: sulfur dioxide, total suspended particulate, fine particulates, sulfation rate, wind speed, wind direction, and temperature. Poplar River air monitoring did not start until July of 1984 because the 1983 Montana Legislature provided funding for only 1

additional year of monitoring which was to commmence when both Coronach units sustained near-capacity operation. The monitoring results are summarized in Table 7.

During the last half of 1984, sulfur dioxide concentrations remained less than both Montana and United States ambient air quality standards. The maximum 1-hour concentration of 8.5 pphm was recorded at the International Boundary site during November. This concentration is approximately one-sixth of the Montana standard. The highest 24-hour concentration of 1.2 pphm also occurred at the International Boundary site, but during August. The Montana 24-hour standard is 10 pphm. A comparison of sulfur dioxide concentrations with Class II Prevention of Significant Deterioration increments demonstrates that the 24-hour concentration is the averaging time which consumes the most increment. The 1.2 pphm 24-hour average at the International Boundary site would consume 35 percent of the available increment. All of the higher sulfur dioxide concentrations noted above occurred with northwest winds, indicating that the Saskatchewan Power Corporation generating facilities were the source.

The Montana and United States standards for total suspended particulates were not exceeded at any of the three monitoring sites. The highest 24-hour concentration was 114 $\mu g/m^3$ recorded on December 20, 1984, at the Richardson site. The Hanrahan site recorded the highest geometric and arithmetic means at 19.4 and 27.3 $\mu g/m^3$, respectively. The levels of total suspended particulates observed during 1984 are low and representative of rural Montana.

In July 1984, an extended network of lead dioxide sulfation plates was installed in the Poplar River area. The sulfation plate network included the existing three primary monitoring sites and five addi-

Table 7. Summary of Air Quality Monitoring Results during 1984 in Montana.

Sulfur Dioxide (pphm)

Site	Highest 1-hr.	Highest 3-hr.	Highest 24-hr.	Annual Average
Border (6)[1]	8.5	4.4	1.2	0.1
Hanrahan (6)[1]	4.8	3.2	1.0	0.2

Sulfation Rate (mg/100 cm^2/day)

Site	July	Aug.	Sept.	Oct.	Nov.	Dec.
Richardson	.010	.000	.000	.000	.000	.000
Microwave Tower	.000	.035	.015	.000	.000	.000
Flaxville	.000	.010	.005	.000	.025	.000
TV Tower	.010	.025	.005	.000	.015	.000
Scobey Downtown	.010	.030	.040	.000	.080	.000
Four Buttes	.005	.010	.000	.000	.000	.000
Border	.015	.035	.000	.000	.045	.000
Border (SO_2)[2]	.0013	.0017	.0002	.0002	.0012	.0003
Hanrahan	.005	.040	.005	.000	.035	.000
Hanrahan (SO_2)[2]	.0007	.0015	.0021	.0031	.0023	.0011

Total Suspended Particulate ($\mu g/m^3$)

Site	Highest 24-hr.	2nd Highest 24-hr.	Geometric Mean	Arithmetic Mean
Border (6)[1]	54	48	16.4	23.3
Hanrahan (6)[1]	89	84	19.4	27.3
Richardson (6)[1]	114	62	17.2	25.4

NOTES:

[1] Parentheses denote the number of sample months.
[2] The monthly sulfur dioxide averages measured by the continuous sulfur dioxide analyzers are presented below the corresponding sulfation rate data for comparison purposes.

tional locations: the Microwave Tower, Flaxville, the TV Tower, Four Buttes, and Scobey Downtown. The objectives were to use sulfation rates to obtain a broad geographical indication of sulfur dioxide concentrations and to investigate the relationship between sulfation rate and sulfur dioxide concentrations. Montana anticipates that funding will not be available in the future for continuous sulfur dioxide monitoring. Therefore, Montana hoped that sulfation rate might prove to be an inexpensive substitute.

Over the last 6 months of 1984, sulfation rates were only slightly above detectable levels. The highest monthly value was 0.080 milligram per 100 centimetre squared per day (mg/100 cm^2/day) at the Scobey downtown site during November. Although levels were low, there appears to be a direct relationship between sulfation rate and sulfur dioxide at the Border site. Similar data from the Hanrahan site indicates no relationship.

ANNEX I

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

CANADA - UNITED STATES

September 23, 1980

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

I. PURPOSE

This Arrangement will provide for the exchange of data collected as described in the attached Technical Monitoring Schedules in water quality, water quantity and air quantity monitoring programs being conducted in Canada and the United States at or near the International Boundary in response to the Saskatchewan Power Corporation development. This Arrangement will also provide for the dissemination of the data in each country and will assure its comparability and assist in its technical interpretation.

The Arrangement will replace and expand upon the quarterly information exchange program instituted between Canada and the United States in 1976.

II. PARTICIPATING GOVERNMENTS

Governments and government agencies participating in the Arrangement are:

Government of Canada: Environment Canada
Government of the Province of Saskatchewan: Saskatchewan Environment
Government of the United States of America: U.S. Geological Survey
Government of the State of Montana: Executive Office

III. POPLAR RIVER MONITORING COMMITTEE: TERMS OF REFERENCE

A binational committee called the Poplar River Bilateral Monitoring Committee will be established to carry out responsibilities assigned to it under this Arrangement. The Committee will operate in accordance with the following terms of reference:

A. Membership

The Committee will be composed of four representatives, one from each of the participating Governments. It will be jointly chaired by the Government of Canada and the Government of the United States. There will be a Canadian Section and a United States Section. The participating Governments will notify each other of any changes in membership on the Committee. Cochairmen may by mutual agreement invite agency technical experts to participate in the work of the Committee.

The Governor of the State of Montana may also appoint a chief elective official of local government to participate as an ex officio member of the Committee in its technical deliberations. The Saskatchewan Minister of the Environment may also appoint a similar local representative.

B. Functions of the Committee

The role of the Committee will be to fulfill the purpose of the Arrangement by ensuring the exchange of monitored data in accordance with the attached Technical Monitoring Schedules, and its collation and technical interpretation in reports to Governments on implementation of the Arrangement. In addition, the Committee will review the existing monitoring systems to ensure their adequacy and may recommend to the Canadian and United States Governments any modifications to improve the technical monitoring schedules.

1. Information Exchange

Each Cochairman will be responsible for transmitting to his counterpart Cochairman on a regular, and not less than quarterly basis, the data provided by the cooperative monitoring agencies in accordance with the Technical Monitoring Schedules.

2. Reports

(a) The Committee will prepare a joint Annual Report to the participating governments, and may at any time prepare joint Special Reports.

(b) Annual Reports will

i) summarize the main activities of the Committee in the year under Report and the data which has been exchanged under the Arrangement;

ii) draw to the attention of the participating governments any definitive changes in the monitored parameters, based on collation and technical interpretation of exchanged data (i.e. the utilization of summary, statistical and other appropriate techniques);

iii) draw to the attention of the participating governments any recommendations regarding the adequacy or redundancy of any scheduled monitoring operations and any proposals regarding modifications to the Technical Monitoring Schedules, based on a continuing review of the monitoring programs including analytical methods to ensure their comparability.

c) Special Reports may, at any time, draw to the attention of participating governments definitive changes in monitored parameters which may require immediate attention.

d) Preparation of Reports

Reports will be prepared following consultation with all committee members and will be signed by all Committee members. Reports will be separately forwarded by the Committee Cochairmen to the participating governments. All annual and special reports will be so distributed.

3. Activities of Canadian and United States Sections

The Canadian and United States section will be separately responsible for:

(a) dissemination of information within their respective countries, and the arrangement of any discussion required with local elected officials;

(b) verification that monitoring operations are being carried out in accordance with the Technical Monitoring Schedules by cooperating monitoring agencies;

(c) receipt and collation of monitored data generated by the cooperating monitoring agencies in their respective countries as specified in the Technical Monitoring Schedules;

(d) if necessary, drawing to the attention of the appropriate government in their respective countries any failure to comply with a scheduled monitoring function on the part of any cooperating agency under the jurisdiction of that government, and requesting that appropriate corrective action be taken.

IV. PROVISION OF DATA

In order to ensure that the Committee is able to carry out the terms of this Arrangement, the participating governments will use their best efforts to have cooperating monitoring agencies, in their respective jurisdictions provide on an ongoing basis all scheduled monitored data for which they are responsible.

V. TERMS OF THE ARRANGEMENT

The Arrangement will be effective for an initial term of five years and may be amended by agreement of the participating governments. It will be subject to review at the end of the initial term and will be renewed thereafter for as long as it is required by the participating governments.

ANNEX 2

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1985

CANADA - UNITED STATES

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PREAMBLE

The Technical Monitoring Schedule lists those water quantity, water quality and air quality monitoring locations and parameters which form the basis for information exchange and reporting to Governments. The structure of the Committee responsible for ensuring the exchange takes place is described in the Poplar River Cooperative Monitoring Arrangement.

The monitoring locations and parameters listed herein have been reviewed by the Poplar River Bilateral Monitoring Committee and represent the basic technical information needed to identify any definitive changes in water quantity, water quality and air quality at the International Boundary. The Schedule was initially submitted to Governments for approval as an attachment to the 1981 report to Governments. Changes in the sampling locations and parameters may be made by Governments based on the recommendations of the Committee.

Significant additional information is being collected by agencies on both sides of the International Boundary, primarily for project management or basin-wide baseline data purposes. This additional information is usually available upon request from the collecting agency and forms part of the pool of technical information which may be drawn upon by Governments for specific study purposes. Examples of additional information are water quantity, water quality, groundwater and air quality data collected at points in the Poplar River basin not of direct concern to the Committee. In addition, supplemental information on parameters such as vegetation, soils, fish and waterfowl populations and aquatic vegetation is also being collected on either a routine or specific studies basis by various agencies.

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1985

CANADA

STREAMFLOW MONITORING

Responsible Agency: Environment Canada

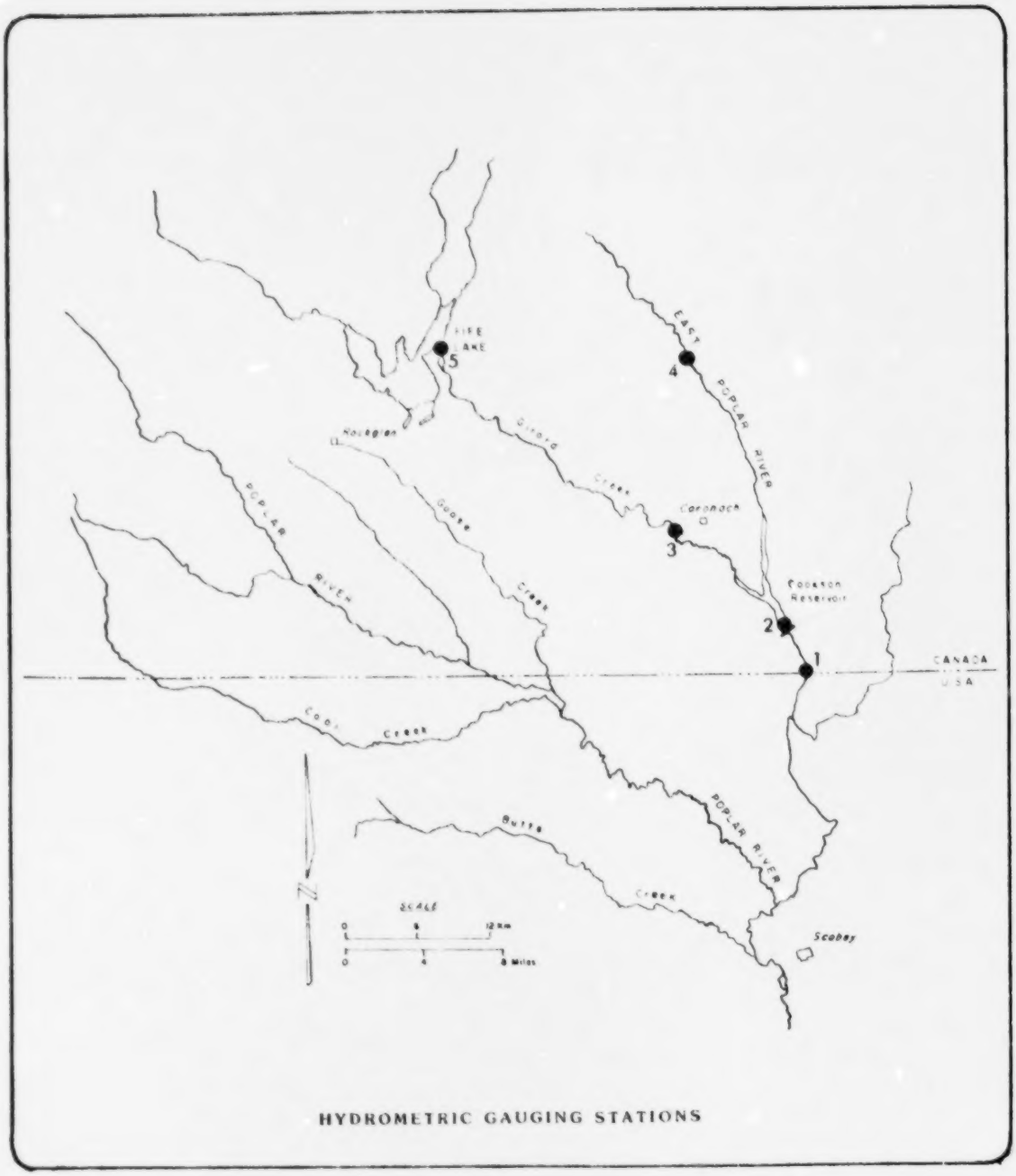
Daily mean discharge or levels and instantaneous monthly extremes as normally published in surface water data publications.

No. on Map	Station No.	Station Name
1.	11AE003 (06178500)	East Poplar River at International Boundary
2.	11AE013	Cookson Reservoir near Coronach
3.	11AE015	Girard Creek near Coronach
4.	11AE014	East Poplar River above Cookson Reservoir

Responsible Agency: Saskatchewan Water Corporation

5.	*	Fife Lake Overflow

* - Miscellaneous measurements of outflow to be made by SDOE during periods of outflow only.



HYDROMETRIC GAUGING STATIONS

SURFACE WATER QUALITY MONITORING

Sampling Locations

Responsible Agency: Saskatchewan Environment

No. on Map	Station No.	Station Name
1	01SK02000002	Fife Lake Overflow
2	00SK02000012	Girard Creek South of Town of Coronach
3	05SK02000008	Upper End of Cookson Reservoir at Highway 36
4	05SK02000004	Cookson Reservoir near Dam
5	00SK02000003	East Poplar River at culvert immediately below Cookson Reservoir

Responsible Agency: Environment Canada

6	00SA11AE0008	East Poplar River at International Boundary

Parameters

Responsible Agency: Saskatchewan Environment

ESQUADAT* Code	Parameter	Analytical Method	Sampling Station No:	Frequency 1	2	3	4	5
10151	Alkalinity-pheno	Pot. Titration		OF	Q	Q	Q	Q
10101	Alkalinity-tot	Pot. Titration		OF	Q	Q	Q	Q
13004	Aluminum tot	AA-direct			A	A	A	A
33004	Arsenic-tot	Flameless-A.A.			A	A	A	A
06201	Bicarbonates	Calculated		OF	Q	Q	Q	Q
05451	Boron-tot	ICPA		W	Q	Q	Q	Q
48002	Cadmium-tot	AA-Solvent extract (MIBK)			A	A	A	A
20103	Calcium	AA-Direct		OF	Q	Q	Q	Q
06052	Carbon-tot Inorg	IR		OF	Q	Q	Q	Q
06005	Carbon-tot Org	IR		OF	Q	Q	Q	Q
06301	Carbonates	Calculated		OF	Q	Q	Q	Q
17203	Chloride	Colourimetery		OF	Q	Q	Q	Q
06711	Chlorophyll 'a'	Colourimetery			Q	Q	Q	Q
24004	Chromium-tot	AA-direct			A	A	A	A
36012	Coliform-fec	MF		OF	Q	Q	Q	Q
36002	Coliform-tot	MF		OF	Q	Q	Q	Q
02041	Conductivity	Conductivity meter		W	Q	Q	Q	Q
29005	Copper-tot	AA-Solvent extract (MIBK)			A	A	A	A
09105	Flouride	Specific ion electrode			A	A	A	A
82002	Lead-tot	AA-Solvent extract (MIBK)			A	A	A	A
12102	Magnesium	AA-direct		OF	Q	Q	Q	Q
80011	Mercury-tot	Flameless AA			A	A	A	A
42005	Molybdenum	AA-Solvent Extract (MIBK)			A	A	A	A
07015	N-TKN	Colourimetry		OF	Q	Q	Q	Q
10401	NFR	Gravimetric		OF	Q	Q	Q	Q
10501	NFR (F)	Gravimetric		OF	Q	Q	Q	Q
28002	Nickel-tot	AA-Solvent extract (MIBK)		OF	Q	Q	Q	Q
07110	Nitrate + NO_2	Colourimetry		OF	Q	Q	Q	Q
06521	Oil and Grease	Pet. Ether Extraction			A	A	A	A
08102	Oxygen-diss	Meter		OF	Q	Q	Q	Q
15406	Phosphorus-tot	Colourimetry		OF	Q	Q	Q	Q
19103	Potassium	Flame Photometery		OF	Q	Q	Q	Q
34005	Selenium-Ext	Hydride Generation			A	A	A	A
11002	Sodium	Flame Photometry		OF	Q	Q	Q	Q
16306	Sulphate	Colourimetry		OF	Q	Q	Q	Q
10451	TDS	Gravimetric		OF	Q	Q	Q	Q
0206YZ	Temperature	Thermometer		OF	Q	Q	Q	Q
23004	Vanadium-tot	AA-Direct			A	A	A	A
30005	Zinc-tot	AA-Solvent extract (MIBK)			A	A	A	A
10301	pH	Electrometric		W	Q	Q	Q	Q

* Computer storage and retrieval system - Saskatchewan Environment

Symbols: W - Weekly during overflow; OF - once during each period of overflow greater than 2 weeks' duration; Q - quarterly; A - annually in the fall; AA - atomic absorption; IR - infrared; Pot - potentiometric; NFR - nonfilterable residue NFRF - nonfilterable residue, fixed.

AA - Solvent Extract (MIBK): Sample digested with HNO_3 and extracted with methyl isobutyl ketone.

ICPA - Plasma emmission

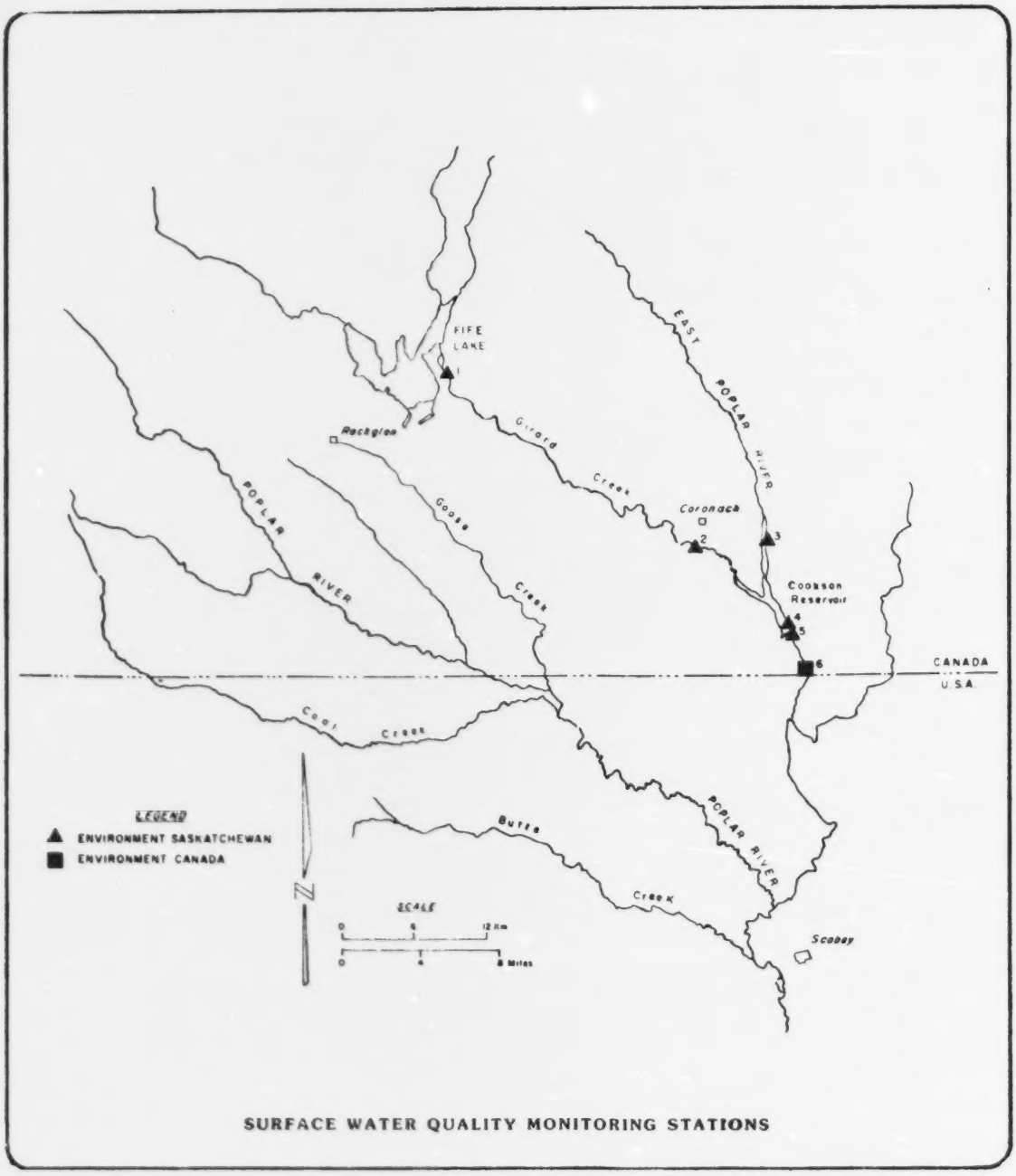
MF - membrane filtration

PARAMETERS (Continued)

Responsible Agency: Environment Canada

NAQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No: 6
10151	Alkalinity-pheno	Potentiometric	M
10106	Alkalinity-tot	IR Detector	M
13102	Aluminum-Diss.	AA-Direct	M
07569	Ammonia-Free	Calculated	M
07506	Ammonia-tot	Electrometric	M
33108	Arsenic-diss	Plasma	M
56001	Barium-tot	AA Direct	M
06201	Bicarbonates	Calculated	M
05105	Boron-diss	Carminic Acid	M
48002	Cadmium-tot	AA Solv. Ext.	M
20103	Calcium	AA-Direct	M
06401	Carbon Dioxide	Calculated	M
06902	Carbon-partic	Elemental Analyzer	M
06002	Carbon-tot Org	Calculated	M
06301	Carbonates	Calculated	M
17206	Chloride	Colourimetric	M
06717	Chlorophyll a	Spectrophotometric	M
24003	Chromium-tot	AA-Solv. Ext.	M
27002	Cobalt-tot	AA Solv. Ext.	M
36012	Coliform-fec	MF	M
36002	Coliform-tot	MF	M
02021	Colour	Comparator	M
02041	Conductivity	Wheatstone Bridge	M
29005	Copper-tot	AA-Solv. Ext.	M
06604	Cyanide	UV-Colourimetric	M
09106	Fluoride	Electrometric	M
10602	Hardness	Calculated	M
08501	Hydroxide	Calculated	M
26104	Iron-diss	AA-direct	M
82002	Lead-tot	AA-Solv. Ext.	M
12102	Magnesium	AA-direct	M
25104	Manganese-diss	AA-direct	M
80011	Mercury-tot	Flameless AA	M
07902	N-particulate	Elemental Analyzer	M
07651	N-tot diss	UV Colourimetric	M
10401	NFR	Gravimetric	M
28002	Nickel-tot	AA-Solv. Ext.	M
07110	Nitrate	Colourimetric	M
07603	Nitrogen-tot	Calculated	M
180XX	Organo Chlorines	GC	M
08101	Oxygen-diss	Winkler	M
15901	P-particulate	Calculated	M
15103	P-tot diss	Colourimetric	M
06535	Phenolics	Colourimetric	M
185XX	Phenoxy Herbicides	GC	M
15406	Phosphorus-tot	Colourimetric	M
19103	Potassium	Flame Emission	M
18601	Piccoram	GC	M
11250	Percent Sodium	Calculated	M
00210	Sat Index	Calculated	M
34108	Selenium-diss	Plasma	M
14102	Silica	Colourimetric	M
11103	Sodium	Flame Emission	M
00211	Stab Index	Calculated	M
16306	Sulphate	Colourimetric	M
00202	TDS	Calculated	M
02061	Temperature	Alcohol	M
02073	Turbidity	Nephelometric	M
23002	Vanadium-tot	AA-Solv. Ext.	M
30005	Zinc-tot	AA-Solv. Ext.	M
10301	pH	Electrometric	M
92111	Uranium	Flurometric	MC

*Computer storage and retrieval system - Environment Canada
Symbols: M-Monthly; AA-atomic absorption; MF-membrane filtration; UV-ultraviolet; NFR-nonfilterable residue; GC-gas chromatography; MC-Monthly Composite; IR-infrared



SURFACE WATER QUALITY MONITORING STATIONS

GROUND WATER QUALITY MONITORING

Sampling Locations

Responsible Agency: Saskatchewan Environment

Sampling Frequency: Annually

Station Description

Station	SPC Piezometer No.	Sampling Elevation (m)	Material
8a	C726A	746.338	unoxidized till
	C726C	752.739	oxidized till
	C726D	755.543	oxidized till
8a	C726E	738.725	empress gravel
9a	C728A	753.405	oxidized till
	C728B	743.265	unoxidized till
	C728C	747.645	mottled till
	C728D	752.305	oxidized till
9a	C728E	739.912	empress gravel
2a	C712B	746.112	oxidized till
2b	C718	748.385	mottled till
2c	C719	747.715	oxidized till
C533	C533	740.441	empress gravel
C534	C534	753.499	till
18	C741	735.153	empress gravel
19	C735	753.789	empress gravel
21	C742	741.800	empress gravel

Parameters

Responsible Agency: Saskatchewan Environment

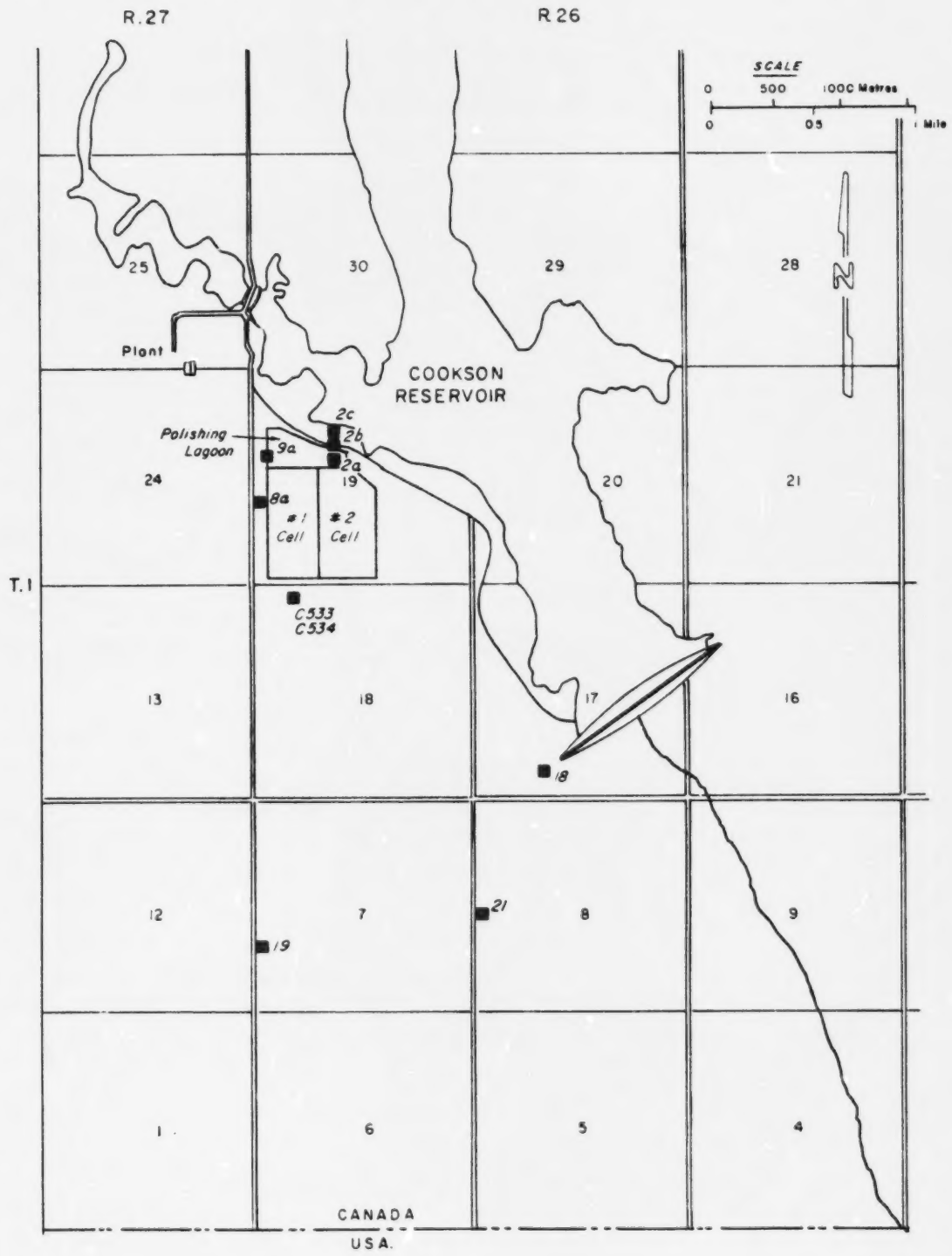
ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No: Piezometers
10101	Alkalinity-tot	Pot-Titration	A
13105	Aluminum-Diss	AA-Direct	3
33104	Arsenic-Diss	Flameless AA	A
56104	Barium-Diss	AA-Direct	A
06201	Bicarbonates	Calculated	A
05106	Boron-diss	Colourimetry	3
48102	Cadmium-Diss	AA-Solvent Extract (MIBK)	A
20103	Calcium-Diss	AA-direct	A
06301	Carbonates	Calculated	A
17203	Chloride-Diss	Colourimetry	A
24104	Chromium-Diss	AA-Direct	A
27102	Colbalt-Diss	AA-Solvent Extract (MIBK)	A
02011	Colour	Comparator	A
02041	Conductivity	Conductivity meter	3
29105	Copper-Diss	AA-Solvent Extract (MIBK)	A
09105	Fluoride-Diss	Specific Ion Electrode	A
26014	Iron-Diss	AA-Direct	A
82103	Lead-Diss	AA-Solvent Extract (MIBK)	A
03102	Lithium-Diss	Flame Photometry	A
12102	Magnesium-Diss	AA-Direct	A
25104	Manganese-Diss	AA-Direct	A
80111	Mercury-Diss	Flameless AA	A
42102	Molybdenum-Diss	AA-Solvent extract (N-Butyl acetate)	A
28102	Nickel-Diss	AA-Solvent extract (MIBK)	A
07110	Nitrate-N	Colourimetry	A
10301	pH	Electrometric	3
19103	Potassium-Diss	Flame Photometry	A
34105	Selenium-Diss	Hydride generation	A
14102	Silica-Diss	Colourimetry	A
11103	Sodium-Diss	Flame Photometry	A
38101	Strontium-Diss	AA-Direct	3
16306	Sulphate-Diss	Colourimetry	3
10451	TDS	Gravimetric	3
92111	Uranium-Diss	Fluorometry	3
23104	Vanadium-Diss	AA-Direct	A
97025	Water Level		A
30105	Zinc-Diss	AA-Solvent Extract (MIBK)	A

No zinc or iron for piezometers C533 or C534

* Computer Storage and Retrieval System - Saskatchewan Environment

Symbols: AA - atomic absorption. A - Annually. 3 - Three times per year

AA-Solvent Extract (MIBK): sample acidified and extracted with Methyl Isobutyl Ketone



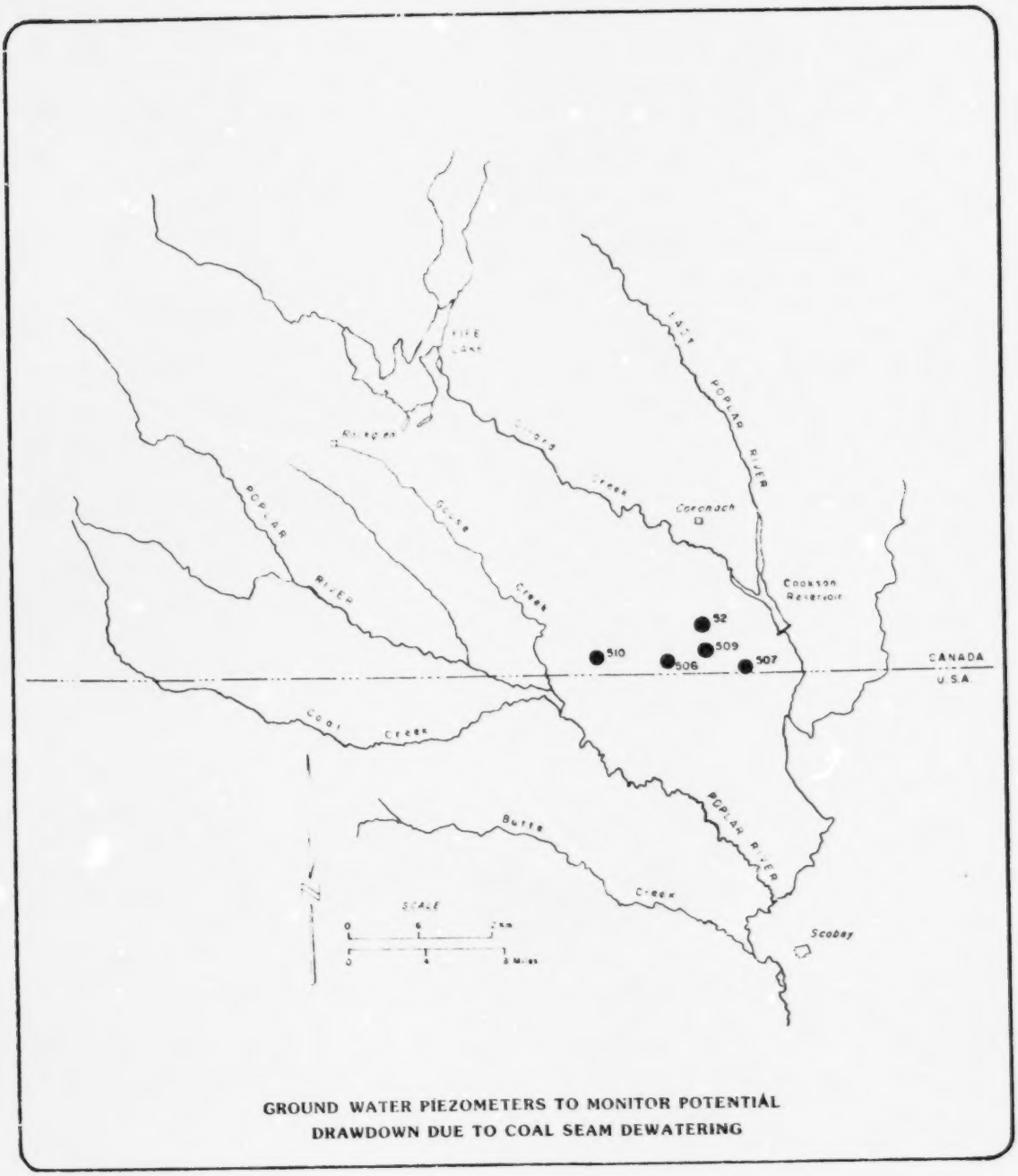
GROUND WATER QUALITY MONITORING

GROUND WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING

Responsible Agency: Saskatchewan Water Corporation

Measurement Frequency: Quarterly

SPC Piezometer No.	Station Number	Location	Sampling Elevation (m)	Perforation Zone (depth in metres)
52	52	NW14-1-27W3	738.43	43 - 49 (in coal)
506	506A	SW4-1-27W3	748.27	81 - 82 (in coal)
507	507	SW6-1-26W3	725.27	34 - 35 (in coal)
509	509	NW11-1-27W3	725.82	76 - 77 (in coal)
510	510	NW1-1-28W3	769.34	28 - 29 (in layered coal and clay)



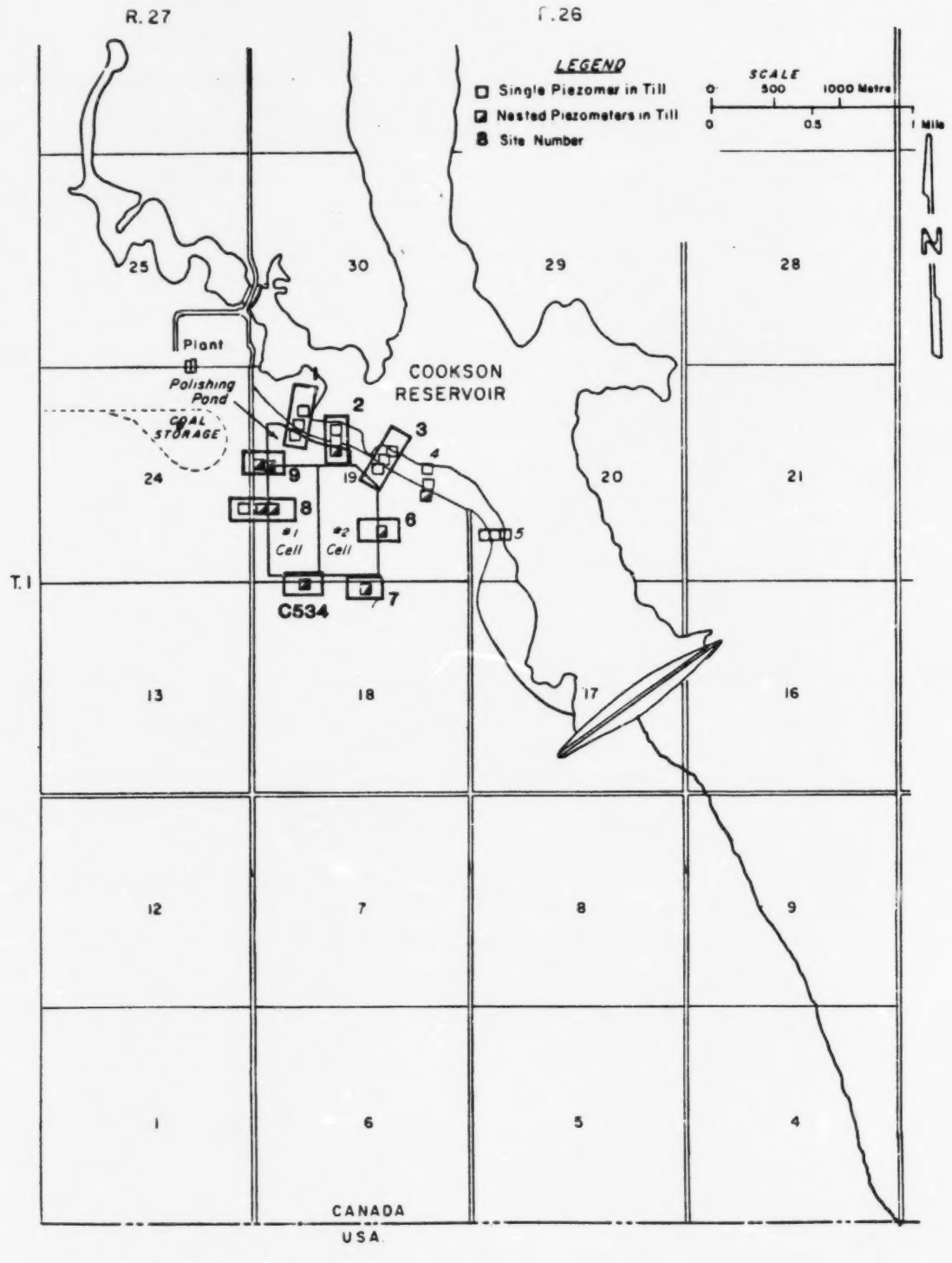
GROUND WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING

GROUND WATER PIEZOMETER LEVEL MONITORING - ASH LAGOON AREA

SCHEDULE A - PIEZOMETERS IN TILL

Responsible Agency: Saskatchewan Environment

Station	SPC Piezometer No.	Frequency of Measurement
1a	C716	All piezometer levels are measured quarterly
1b	C717	
1c	C711	
$2a_1$	C712A	
$2a_2$	C712B	
$2a_3$	C712C	
$2a_4$	C712D	
2b	C718	
2c	C719	
3a	C713	
3b	C720	
3c	C721	
$6a_1$	C763A	
$6a_2$	C763B	
$6a_3$	C763C	
$6a_4$	C763D	
$7a_1$	C729A	
$7a_2$	C729B	
$7a_3$	C729C	
$7a_4$	C729D	
C534	C534	
$8a_1$	C730A	
$8a_2$	C730B	
$8a_3$	C730C	
$8a_4$	C730D	
$8b_1$	C727A	
$8b_2$	C727B	
$8b_3$	C727C	
$8c_1$	C726A	
$8c_2$	C726B	
$8c_3$	C726C	
$8c_4$	C726D	
8d	C748	
$9a_1$	C764A	
$9a_2$	C764B	
$9a_3$	C764C	
$9a_4$	C764D	
$9b_1$	C728A	
$9b_2$	C728B	
$9b_3$	C728C	
$9b_4$	C728D	



POPLAR RIVER POWER STATION ASH LAGOON MONITORING STUDY

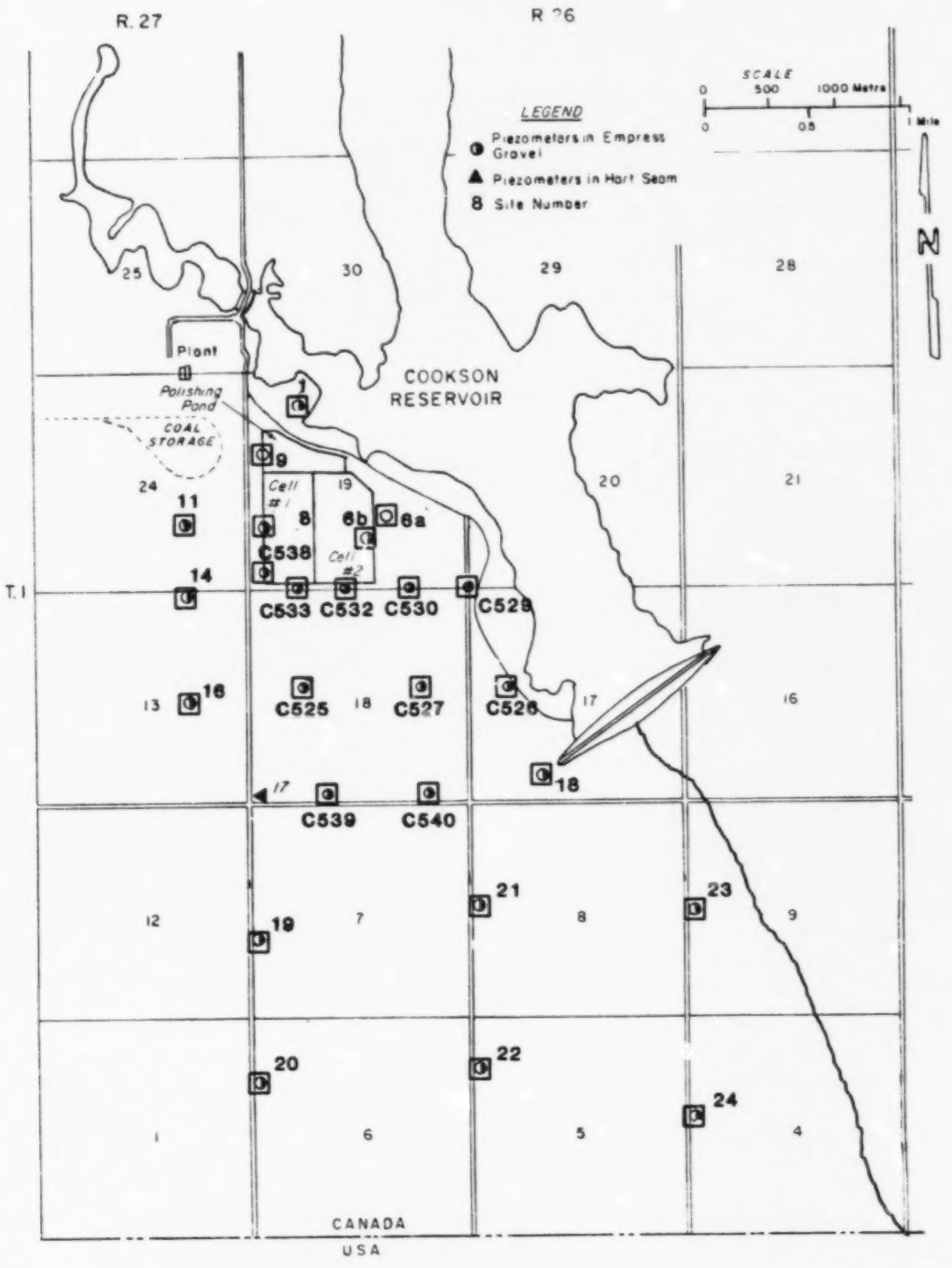
PIEZOMETER INSTALLATION SITES
SCHEDULE "A" PIEZOMETERS IN TILL

GROUND WATER PIEZOMETER LEVEL MONITORING - ASH LAGOON AREA AND INTERNATIONAL BOUNDARY AREA

SCHEDULE B - PIEZOMETERS IN EMPRESS GRAVEL

Responsible Agency: Saskatchewan Environment

Station	SPC	
Immediate Ash Lagoon Area	Piezometer No.	Frequency of Measurement
1	C721	All piezometers are monitored quarterly
6a	C763E	
6b	C765A	
C529	C529	
C530	C530	
C532	C532	
C533	C533	
C538	C538	
8	C730E	
9	C728E	
West of Ash Lagoon Area		
11	C743	
14	C740	
16	C756	
South of Ash Lagoon Area		
C525	C525	
C526	C526	
C527	C527	
C539	C539	
C540	C540	
18	C741	
19	C735	
20	C736	
21	C742	
22	C733	
23	C732	
24	C734	



POPLAR RIVER POWER STATION ASH LAGOON MONITORING STUDY

PIEZOMETER INSTALLATION SITES
SCHEDULE "B" PIEZOMETERS IN EMPRESS GRAVEL

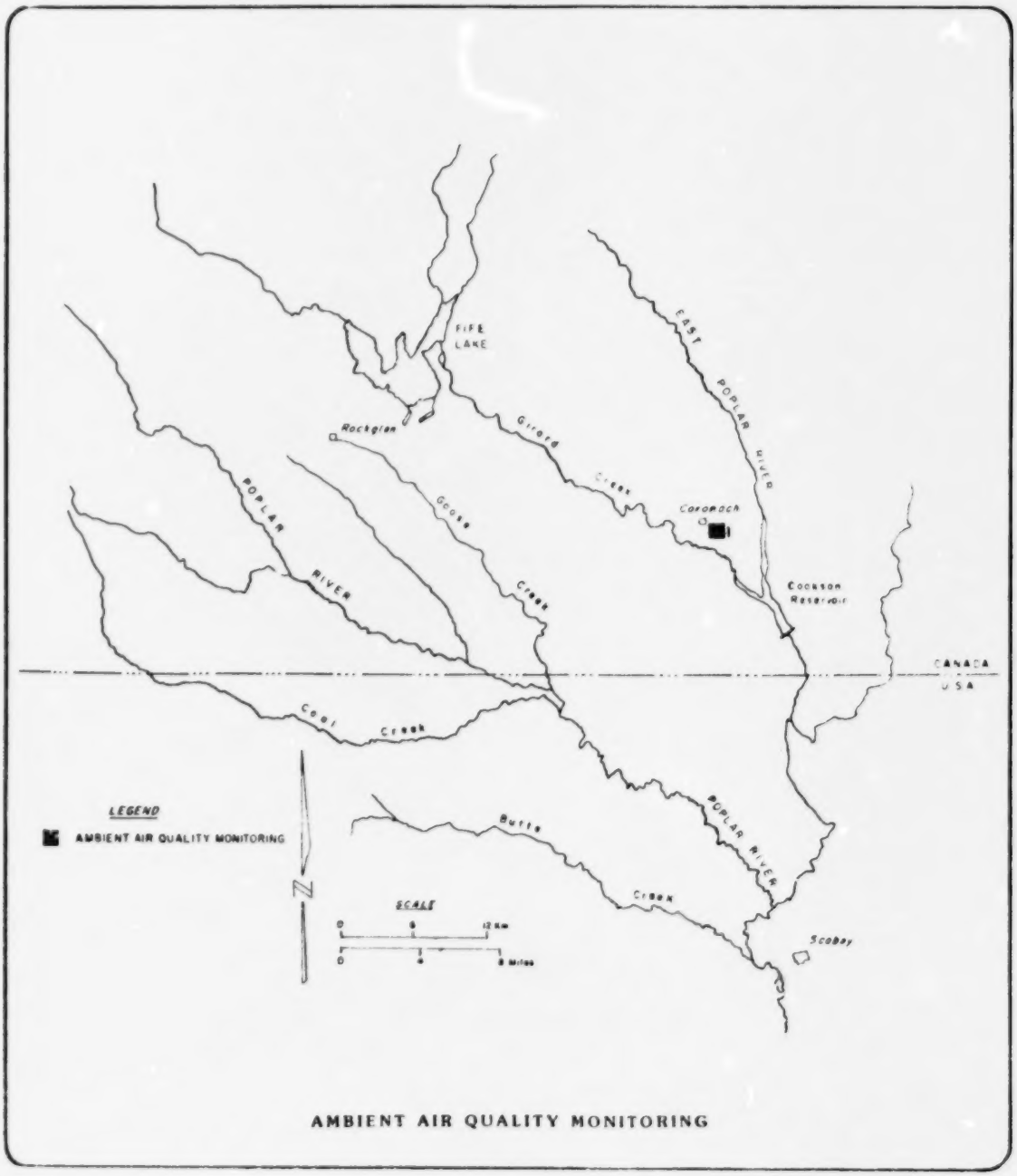
AMBIENT AIR QUALITY MONITORING

Responsible Agency: Saskatchewan Environment

No. on Map	Location	Parameters	Reporting Frequency
1	Coronach	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulates	24 hour samples on a 6 day cycle.

METHODS

Sulphur Dioxide	Saskatchewan Environment Colourimetric Titration
Total Suspended Particulates	Saskatchewan Environment High Volume Method



AMBIENT AIR QUALITY MONITORING

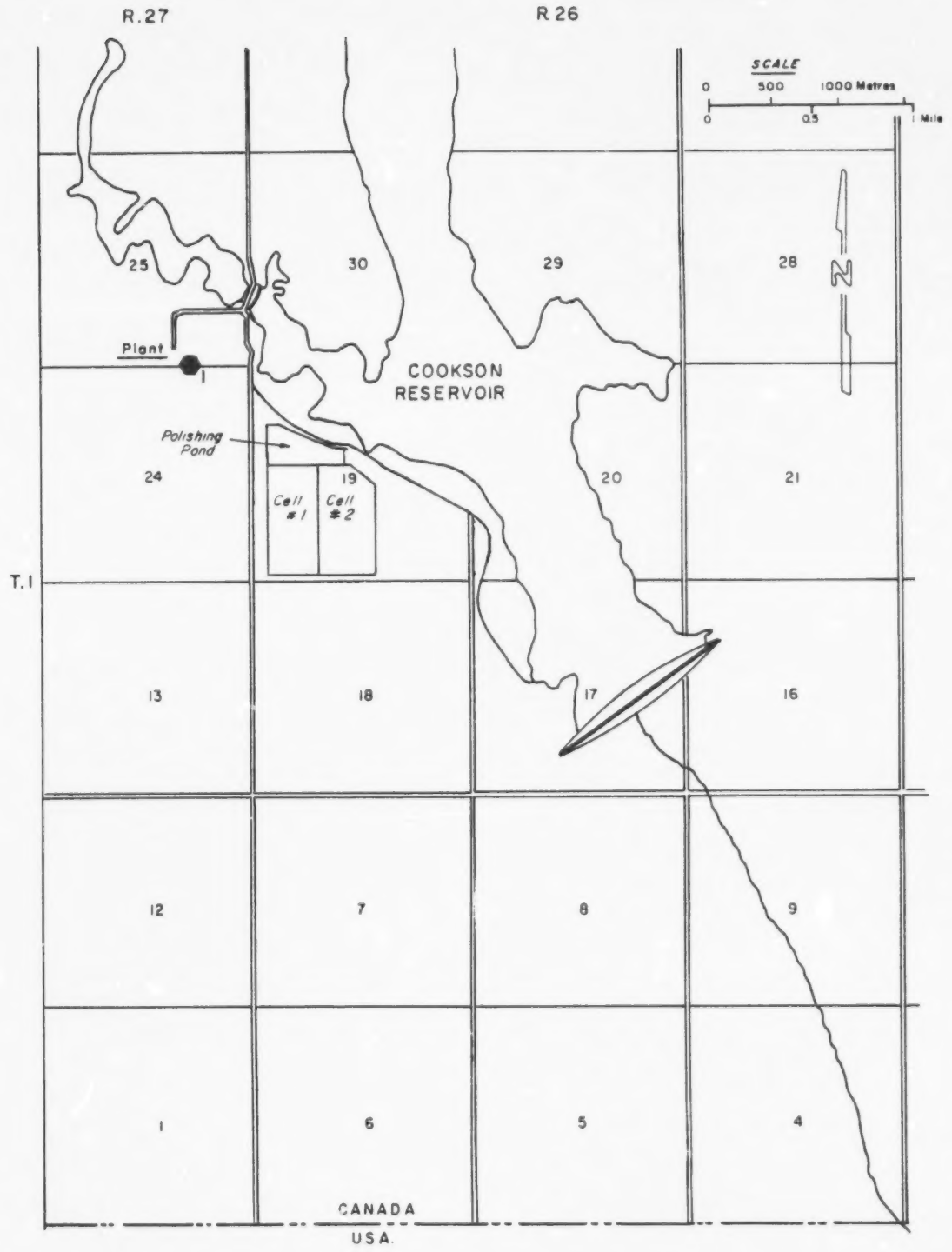
SOURCE EMISSION MONITORING

Responsible Agency: Saskatchewan Environment

No. on Map	Station Location	Parameters	Sampling Frequency
1	At Poplar River Power Plant	Sulphur Dioxide Nitrogen Dioxide, Opacity.	Continuous reported as Hourly Averages

METHODS

Sulphur Dioxide	Saskatchewan Environment - Ultraviolet Absorption
Nitrogen Dioxide	Saskatchewan Environment - Chemiluminescence
Opacity	Saskatchewan Environment - Optical



SOURCE EMISSION MONITORING

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

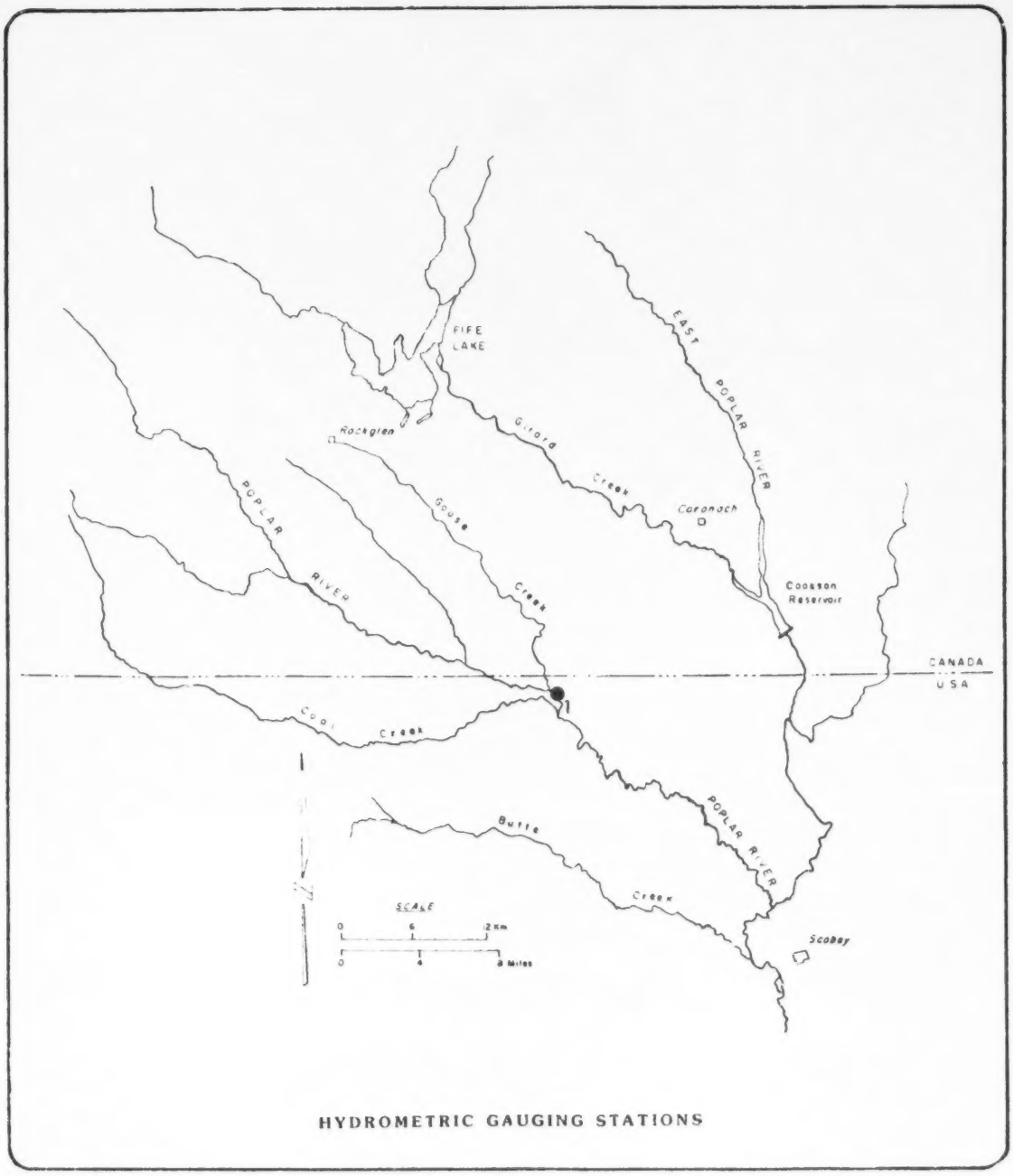
1985

UNITED STATES

STREAMFLOW MONITORING

Responsible Agency: United States Geological Survey

No. on Map	Station Number	Station Name
1	06178000 (11AE008)	Poplar River at International Boundary



HYDROMETRIC GAUGING STATIONS

SURFACE WATER QUALITY MONITORING

Station Location

Responsible Agency: U.S. Geological Survey

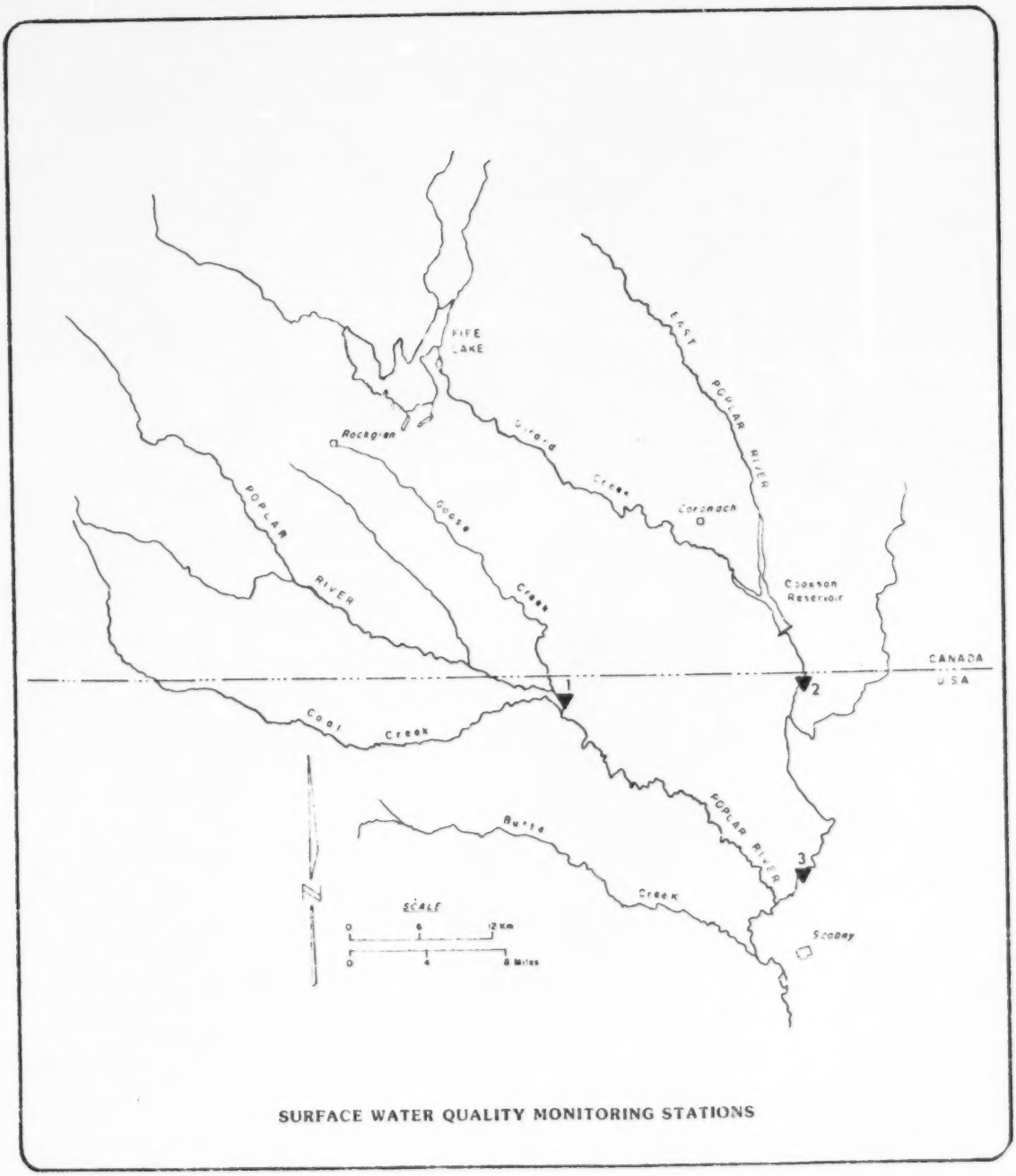
No. on Map	USGS Station No.	Station Name
1	06178000	Poplar River at International Boundary
2	06178500	East Poplar River at International Boundary
3	06179000	East Poplar River near Scobey

PARAMETERS

WATSTORE* Code	Parameter	Analytical method	No.	Sampling Frequency 1	2	3
00410	Alkalinity-field	Elect. Titration		M	M	M
90410	Alkalinity-lab	Elect. Titration		M	M	M
01106	Aluminum-diss	AA		SA	SA	SA
00610	Ammonia-tot	Colorimetric		M	M	M
00625	Ammonia+Org N-tot	Colorimetric		M	M	M
01000	Arsenic-diss	AA, hydride		SA	SA	SA
01002	Arsenic-tot	AA, hydride		A	A	A
01010	Beryllium-diss	AA		SA	SA	SA
01012	Beryllium-tot/rec	AA-Persulfate		A	A	A
01020	Boron-diss	Colorimetric		M	M	M
01025	Cadmium-diss	AA		SA	SA	SA
01027	Cadmium-tot/rec	AA-persulfate		A	A	A
00915	Calcium	AA		M	M	M
00680	Carbon-tot Org	Wet Oxidation		SA	SA	SA
00940	Chloride-diss	Ion chromatography		M	M	M
01030	Chromium-diss	AA		SA	SA	SA
01034	Chromium-tot/rec	AA-persulfate		A	A	A
00080	Color	Electrometric, visual		M	M	M
00095	Conductivity	Wheatstone Bridge		M	D	M
01040	Copper-diss	AA		SA	SA	SA
01042	Copper-tot/rec	AA-persulfate		A	A	A
00061	Discharge-inst	Direct measur.		M	M	M
00950	Fluoride	Electrometric		M	M	M
01046	Iron-diss	AA		M	M	M
01045	Iron-tot/rec	AA-persulfate		A	A	A
01049	Lead-diss	AA		SA	SA	SA
01051	Lead-tot/rec	AA-persulfate		A	A	A
00925	Magnesium-diss	AA		M	M	M
01056	Manganese-diss	AA		SA	SA	SA
01055	Manganese-tot/rec	AA-persulfate		A	A	A
01065	Nickel-diss	AA		SA	SA	SA
01067	Nickel tot/rec	AA-persulfate		A	A	A
00615	Nitrite-tot	Ion-chromatography		M	M	M
00630	Nitrate+Nitrite-tot	Colorimetric		M	M	M
00300	Oxygen-diss	Winkler/meter		M	M	M
70507	Phos, Ortho-tot	Colorimetric		M	M	M
00400	pH	Electrometric		M	M	M
00665	Phophorous-tot	Colorimetric		M	M	M
00935	Potassium-diss	AA		M	M	M
00931	SAR	Calculated		M	M	M
80154	Sediment-conc.	Filtration-gravimetric		M	M	M
80155	Sediment-load	Calculated		M	M	M
01145	Selenium-diss	AA, hydride		SA	SA	SA
01147	Selenium tot/rec	AA, hydride		A	A	A
00955	Silica	Colorimetric		M	M	M
00930	Sodium	AA		M	M	M
00945	Sulfate-diss	Colorimetric		M	M	M
70301	Total Dissolved Solids	Calculated		M	M	M
00010	Temp Water	Toluene		M	M	M
00020	Temp Air	Toluene		M	M	M
00076	Turbidity	Nephelometric		M	M	M
80020	Uranium-diss	Fluorimetric		-	NC	-
01090	Zinc-diss	AA		SA	SA	SA
01092	Zinc-tot/rec	AA-persulfate		A	A	A

*Computer storage and retrieval system - USGS

Symbols: C-continuous; D-daily; M-monthly; NC-monthly composite; A-annually at high flow; SA-semi-annually at low and high flow; AA-atomic absorption; tot-total; rec-recoverable; diss-dissolved



SURFACE WATER QUALITY MONITORING STATIONS

GROUND WATER QUALITY MONITORING

Station Locations

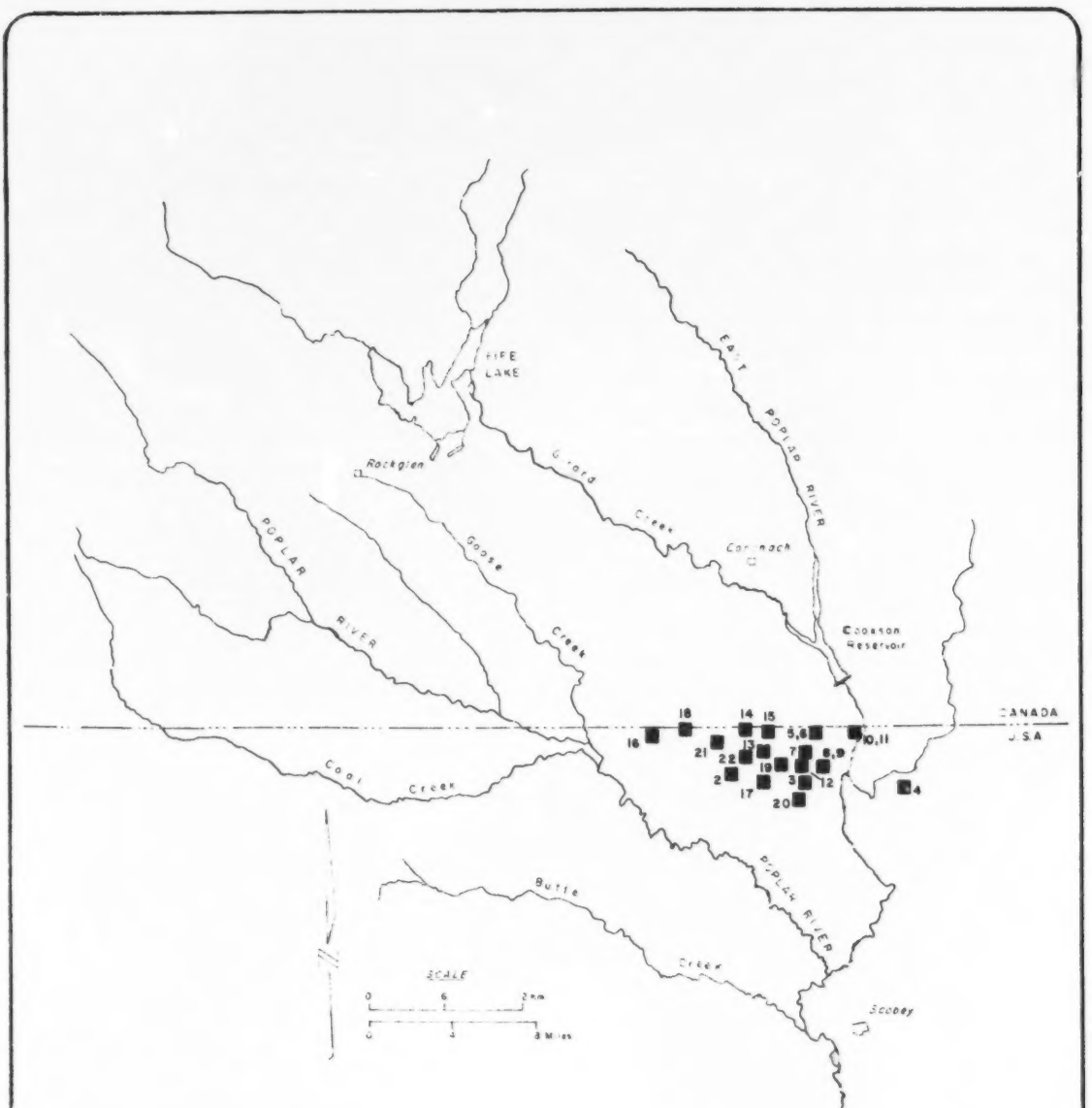
Responsible Agency: Montana Bureau of Mines and Geology

Map Number	Well Location	Total Depth (m)	Casing Diameter (cm)	Aquifer	Perforation Zone (m)
2	37N47E17DABB	79	3.8 PVC	Hart Coal	76-79
3	37N47E23AADD	36	3.8 PVC	Hart Coal	33-36
4	37N48E23BBCC	104	3.8 PVC	Fox Hills-Hell Creek	102-104
5	37N47E1ABBB1	16	10.2 PVC	Alluvium	10-15
6	37N47E1ABBB2	25	10.2 PVC	Hart Coal	19-25
7	37N47E12BBBB	45	10.2 PVC	Hart Coal	39-45
8	37N47E13AADD	14	10.2 PVC	Alluvium	10-13
9	37N47E13ADAA01	43			
		63	10.2 PVC	Fort Union	16-62
10	37N48E5BABB	13	10.2 PVC	Alluvium-Coal	7-13
11	37N48E5AAAA	67	15.2 STEEL	Fox Hills-Hell Creek	65-67
12	37N47E Sec 11 DDDD	26	5.08	Hart Coal	15-18
13	37N47E Sec 3 CCCC	62.5	10.2	Hart Coal	56-59
14	37N47E Sec 4 BBAB	82.6	10.2	Hart Coal	75-78
15	37N47E Sec 3 BBAA	89	10.2	Hart Coal	83-86
16	37N46E Sec 3 ABAB	26	10.2		24-25
17	37N47E Sec 16 DDDD	88	10.6	Hart Coal	80-83
18	37N46E Sec 1 BBBA	90	10.2	Hart Coal	80-82
19	37N47E Sec 15 AAAB	59	10.2	Hart Coal	54-56
20	37N47E Sec 24 CCCC	22	5.08		19-22
21	37N47E Sec 6 DBAA	106	10.2	Hart Coal	100-103
22	37N47E Sec 9 CBCC	21	10.2		18-21

Parameters

Storet* Code	Parameter	Analytical Method	Sampling Frequency Station No.
00440	Bicarbonates	Electrometric Titration	Sample collection is semi-annually for all locations identified above.
01020	Boron-diss	Emission Plasma ICP	
00915	Calcium	Emission Plasma	
00445	Carbonates	Electrometric Titration	The analytical method descriptions are those of the Montana Bureau of Mines and Geology Laboratory where the samples are analyzed.
00940	Chloride	Ion Chromatography	
00095	Conductivity	Wheatstone Brdg	
01040	Copper-diss	Emission Plasma, ICP	
00950	Fluoride	Ion Chromatography	
01046	Iron-diss	Emission Plasma, ICP	
01049	Lead-diss	Emission Plasma, ICP	
01130	Lithium-diss	Emission Plasma, ICP	
00925	Magnesium	Emission Plasma, ICP	
01056	Manganese-diss	Emission Plasma, ICP	
01060	Molybdenum	Emission Plasma, ICP	
00630	Nitrate	Ion Chromatography	
00400	pH	Electrometric	
00935	Potassium	Emission Plasma, ICP	
01145	Selenium-diss	AA	
00955	Silica	Emission Plasma, ICP	
00930	Sodium	Emission Plasma, ICP	
01080	Strontium-diss	Emission Plasma, ICP	
00445	Sulphate	Ion Chromatography	
22703	Uranium	Fusion Flurometric	
00190	Zinc-diss	Emission Plasma, ICP	
70301	TDS	Calculated	

*Computer storage and retrieval system - United States Geological Survey
Symbols: AA-Atomic Absorption; ICP-Inductively Coupled Plasma Unit



GROUND WATER QUALITY MONITORING

GROUND WATER LEVELS TO MONITOR

POTENTIAL DRAWDOWN DUE TO

COAL SEAM DEWATERING

Responsible Agency: Montana Bureau of Mines and Geology

No. on Map	Sampling
2 to 22	Determine water levels quarterly

GROUND WATER PIEZOMETERS TO MONITER POTENTIAL

DRAWDOWN DUE TO COAL SEAM DEWATERING

AMBIENT AIR QUALITY MONITORING

Responsible Agency: State of Montana
Air Quality Bureau

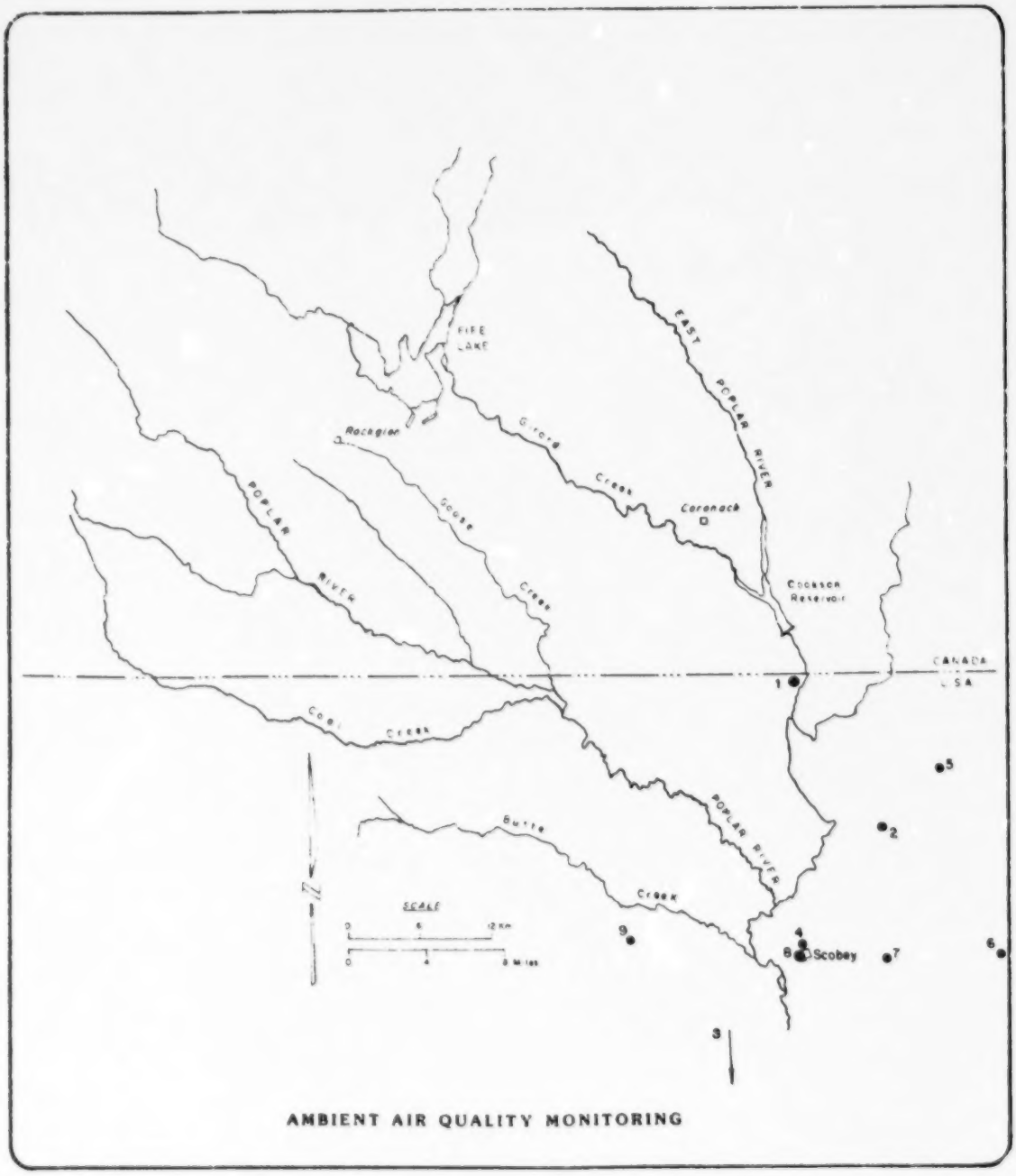
No. on Map	Location	Parameters	Sampling Frequency and Reporting
1	International Boundary	Sulfur dioxide	Hourly averages
		Suspended particulates	24-hour averages
		Fine particulates	24-hour averages
		Sulfation rate	Monthly averages
2	Hanrahan	Sulfur dioxide	Hourly averages
		Suspended particulates	24-hour averages
		Fine particulates	24-hour averages
		Wind speed	Hourly averages
		Wind direction	Hourly averages
		Temperature	Hourly averages
		Sulfation rate	Monthly
3	Ft. Peck Reservation	Sulfur dioxide	Hourly averages
		Suspended particulates	24-hour averages
4	Scobey - Richardson	Suspended particulates	24-hour averages
		Sulfation rate	Monthly averages
5	Microwave Tower	Sulfation rate	Monthly averages
6	Flaxville	Sulfation rate	Monthly averages
7	TV Tower Hill	Sulfation rate	Monthly averages
8	Scobey-Downtown	Sulfation rate	Monthly averages
9	Four Buttes	Sulfation rate	Monthly averages

METHODS

Sulfur Dioxide — EPA Equivalent Method EQSA-0276-009

Total Suspended — EPA Reference Method CFR Title 40 Part 50, Appendix B (State of Montana QA Manual Section 1.1.10 and 1.2.10) 24-hour sample once/6 days

Sulfation Rate — Methods of Air Sampling and Analysis, 2nd Edition, "Tentative Method of Analysis of the Sulfation Rate of the Atmosphere (Lead Dioxide Plate Method - Turbidimetric Analysis), p. 691.



AMBIENT AIR QUALITY MONITORING

ANNEX 3

METRIC CONVERSIONS

METRIC CONVERSION FACTORS

ac	=	4,047 m^2 = 0.4047 ha
ac-ft	=	1,233.5 m^3 = 1.2335 dam^3
C°	=	1.8 F°
cm	=	0.3937 in.
cm^2	=	0.155 in^2
dam^3	=	1,000 m^3 = 0.8107 ac-ft
ft^3	=	28.3171 x $10^{-3}m^3$
ha	=	10,000 m^2 = 2.471 ac
hm	=	100 m = 328.08 ft
hm^3	=	1 x 10^6 m^3
I.gpm	=	0.0758 L/s
in	=	2.54 cm
kg	=	2.20462 lb = 1.1 x 10^{-3} tons
km	=	0.62137 miles
km^2	=	0.3861 mi^2
L	=	0.3532 ft^3 = 0.21997 I. gal = 0.26420 U.S. gal
L/s	=	0.035 cfs = 13.193 I.gpm = 15.848 U.S. gpm
m	=	3.2808 ft
m^2	=	10.7636 ft^2
m^3	=	1,000 L = 35.3144 ft^3 = 219.97 I. gal = 264.2 U.S. gal
m^3/s	=	35.314 cfs
mm	=	0.00328 ft
tonne	=	1,000 kg = 1.1023 ton (short)
U.S. gpm	=	0.0631 L/s

<u>For Air Samples</u>

ppm = 100 pphm = 1000 X (Molecular Weight of substance/24.45) mg/m^3